Terminal Ballistics

A Text and Atlas of Gunshot Wounds

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Acknowledgments

The idea to produce a book such as this came to me some six years ago, but remained exactly that — an idea — for three more years. After collating hundreds of photographic images and talking about producing the book, the moment finally came when I committed myself to the task. Becoming an active member of an amateur pistol club perhaps acted as a catalyst.

This project could not have been completed without the help of many good people. I would like to first thank my colleague and co-author, Karen Byrne, for all her time and effort in initial photography at the postmortem table and later in transferring the images from one form to another. Many photographs have been taken, with literally only a small percentage being chosen for inclusion. This does not include the photographs of paraphernalia that supplement many of the chapters.

I would also like to sincerely thank Caroline Rosenberg for the excellent work performed in Karen's extended absence from the Institute. Caroline literally took over the major role of image processing at a very vital time in this book's production.

Although the majority of images have been derived from my own case work, I am greatly in debt to the many photographs submitted by my esteemed colleagues and fellow forensic pathologists, Professor Stephen Cordner (Director of the Victorian Institute of Forensic Medicine), Associate Professor David Ranson, and Drs. Shelley Robertson, Matthew Lynch, and Michael Burke.

Photographs of ocular trauma were obtained from the Department of Medical Imaging at the Royal Victorian Eye and Ear Hospital. I am extremely grateful for the opportunity to examine its formidable photographic archive and to use relevant photographs for the section on air pistol trauma.

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High velocity centerfire rifle gunshot injury is uncommon in the State of Victoria. I would like to sincerely thank my interstate colleague, Dr. Kevin Lee, now in New South Wales, for his permission to reproduce certain images from this category.

The book could not have been completed without the help of key personnel working from the Firearms Section of the Victoria Forensic Science Centre (VFSC). In particular I would sincerely like to thank Senior Constable Mark Chandler for the supply of certain images related to firearms examination, for the supply of uncommon rounds of ammunition, and for access to the VFSC's vast gun library.

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I would particularly like to thank Gale E. Spring, Associate Professor of Scientific Photography at the Royal Melbourne Institute of Technology University for permission to reproduce his excellent image of a revolver at the instant of discharge. This image may be found in Chapter 22, GSR Sampling and the Ballistics Expert.

Forensic entomology is a relatively new subspeciality. I felt it warranted a short chapter and thus enlisted the help of Dr. Melanie Archer, forensic entomologist to the Victorian Institute of Forensic Medicine. Thank you, Melanie, for your most valuable input.

Every comprehensive text should have an equally comprehensive glossary and for this I gratefully acknowledge the kind permission of Mr. E. Evans, secretary of the Victorian Amateur Pistol Association, to reproduce many of the terms and explanations found in his excellent handbook.

Finally I would like to acknowledge the expertise and technical input of my friend, Oliver Jurga. Without Oliver's help, many of the images in this book would not have been possible.

M.J.D.

Author

Malcolm John Dodd is a senior forensic pathologist at the Victorian Institute of Forensic Medicine, Victoria, Australia. He began his professional career as a medical laboratory technologist majoring in hematology, then undertook basic medical training, graduating from the University of Melbourne Medical School in 1981. After eight years in full time general practice in the outer eastern suburbs of Melbourne, Dr. Dodd retrained as a specialist forensic pathologist, gaining his fellowship from the Royal College of Pathologists of Australasia in 1997. In 2000, he gained the Diploma of Medical Jurisprudence (Pathology) from London.

Dr. Dodd's areas of forensic interest include the investigation of underwater fatalities, the interpretation of gunshot injuries and, in particular, the investigation of war crimes and injustices perpetrated in third world countries. His work overseas includes East Timor, Kosovo and, more recently, the Solomon Islands.

Contributor

Karen Byrne is a professional photographer with six years' experience in the forensic field. She was senior forensic photographer at the Victorian Institute of Forensic Medicine in Melbourne, Australia from 1993 to 2001 where she photographed cases, documenting both the living and the deceased. She also lectured for Monash University and the Royal Melbourne Institute of Technology. Karen has a keen interest in gunshot photography. She has worked closely with the Victoria Police and visited several forensic facilities worldwide, including the highly regarded forensic photography department in Dade County, Florida.

Karen Byrne earned her bachelor of applied science in photography at the Royal Melbourne Institute of Technology. She is also a registered nurse. She currently lives in San Francisco, where she is completing a certificate in multimedia studies at San Francisco State University.

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Preface

Ballistics is the study and science of the passage of projectiles in motion and may be divided into the subsets of internal (interior), external (exterior), and terminal. The passage of the bullet through the barrel of the gun is the subject of internal ballistics. At the instant of exit from the muzzle, the nomenclature changes to exterior ballistics, a most complex field requiring a detailed knowledge of physics and higher mathematics. At the moment of impact with a surface, be it human tissue, wood, masonry, or glass, the study becomes one of terminal ballistics. Terminal ballistics in the setting of forensic pathology is what this book is all about.

Many variables determine a bullet's behavior at the moment of impact with skin, muscle, bone, or viscera. These include the bullet's conformation, size, weight, and velocity; all are factors in determining the degree and severity of trauma. The modern forensic pathologist is required to have knowledge of the many and varied patterns of gunshot-related trauma and there are many excellent textbooks available that fulfill this requirement. Some are literally "stand alone" texts; other general textbooks contain excellent chapters dedicated to the subject.

It has been my long-held belief that a book should be available for the sole purpose of demonstrating the pattern of gunshot trauma in a functional and user-friendly format, with text sufficient to explain phenomena without being laborious. However, it is not enough simply to demonstrate injury patterns without some information on firearms and ammunition. To this end, the first section of this book deals with the types of firearms available, ammunition, and propellant types. This section is not meant to be taken as definitive data but rather as an overview for the practitioner who requires general information only. The chapters dealing with trauma include greater detail.

My initial plan was to produce a text that could deal comprehensively with specific bullet calibers at contact, intermediate, and distant range. Clearly this is not a viable option — a rough estimate of the number of bullet types and projectiles exceeds 1500! To this end, the chapters dealing with injury patterns are grouped into broad categories such as smooth bore, hunting rifle (centerfire), and pistol. There is little point in waxing lyrical about the .38, .357, and 9 mm caliber projectiles separately when all effectively create the same injury pattern.

In addition, I have deliberately included chapters that deal with areas often neglected in other texts. These include chapters on the management of the surgical resection specimen from the survivor victim, the impact of radiology, general principles of crime scene investigation, and the gunshot homicide autopsy.

This book is intended for use by both the trainee and qualified forensic pathologist, the legal fraternity, ballistics investigators within crime scene investigation units, police officers, and those with more than a passing interest in this fascinating subject.

M.J.D.

Part A

Hardware

1 Anatomy of Handguns, Rifles, and Shotguns

The origins of weapons of war powered by explosive force are lost in time. It is widely held that the Chinese discovered the explosive combination of sulfur, saltpeter, and charcoal during the 11th century, and it is regarded by most that this new material, now known as gun powder, was largely used for its pyrotechnic rather than its offensive properties.

The first mention of a cannon appears in a manuscript dated 1326. This rudimentary device is described as a pear- or vase-shaped vessel designed to fire arrows. The cannon almost certainly played a part in the battle of Crecy in 1346.

Documents from the mid-14th century describe the first hand firearm — the so called *hand gonne*. An example of this weapon was recovered from a well at Tannenburg Castle in Hesse, Germany, which was destroyed in 1399. The hand gonne had a short iron or bronze barrel which was tightly held and bound to a wooden staff by iron bands.

The device was manually lit by a taper. One can imagine the blast, recoil, and large amount of acrid smoke that would have been produced. To assist in containing the recoil, an iron hook fixed to the staff could be anchored against the parapet. The bore measured up to 40 mm. in diameter. The projectile may have been a round stone or a metallic ball.

The concept of the lit taper being applied to the flash hole later gave rise to the *match lock* rifle and pistol. The taper was held in place by an S-shaped bar called a serpentine. Pressure on the trigger lowered the lit taper to the flash hole. The disadvantage here was that the taper needed to be glowing at all times to be readily effective.

The next achievement in the development of weapons was the generation of a spark from a spring-driven tinder lighter — the so-called *wheel lock* (1517). The spark derived from striking iron pyrites against a roughened metallic plate. The principle of the wheel lock is still seen today in most cigarette lighters.

Then, in 1612, the *flint lock* was invented. The spark was generated by a fragment of flint striking a roughened metallic surface, thus igniting gun powder at the flash hole.

Many elegant designs and elaborations were developed, but no significant progress was made until the invention of the *percussion cap* during the 19th century. The igniting spark was now generated from a small cap filled with percussion-sensitive chemicals. The cap was placed on a small nipple and struck by a falling hammer when the trigger was released.

The pistols and rifles described previously can be collectively categorized as muzzle loading weapons — that is to say, all propellant, wadding, and projectiles are introduced down through the muzzle, rammed home, and compacted with a wooden rod. From this point onward, *breech loading* weapons, cartridges, and projectiles soon evolved.

In classifying hand held firearms of today, most authorities agree that a broad separation into *long arms* (designed to be braced against the shoulder) and *hand guns* (designed to be fired using one or both hands) is appropriate. Further subdivisions can then be made, depending on whether the barrel of the weapon has a smooth bore or lands and grooves (rifling). The mechanism of advancement of the cartridge into the breech further subdivides these groups.

It is not the intention of the author to provide a detailed treatise on weapon evolution and design; however, the forensic pathologist should be able to describe the basic differences between a shot gun and a rifle and a semiautomatic pistol and a revolver. With this intent in mind, the following basic classification and explanations are provided.

1. Handguns (Pistols)
   - Single shot and double barrel pistols
   - Revolvers
   - Semiautomatic pistols
   - Automatic and machine pistols
   - Air pistols
2. Long Arms
   - Rifles
     Single shot
     Magazine repeaters
       lever action
       slide or pump action
       single shot bolt action
       semiautomatic
       automatic
   - Submachine guns
   - Machine guns
   - Shotguns
     Single barreled

- Double barreled (over and under, side by side)
- Magazine repeating shotguns
  - lever action
  - slide or pump action
  - bolt action
  - self loading or semiautomatic shotguns
- Air rifles

3. Home made, improvised, and illegal weapons

HANDGUNS (PISTOLS)

Any small arm designed to be fired while held in one or both hands is a handgun. The collective term pistol is often used.

Early breech-loading pistols accommodated one cartridge at a time. These are now almost exclusively used by precision target and competition shooters in "free pistol" events. Further examples include the small "purse" pistols and derringers. The latter were often of double-barrel design.

The pistol may be of *break-open* design or have a *bolt action* very similar to the single shot rifle.

Revolvers are common. The working principle of the revolver is that the cartridges are accommodated in chambers built into a revolving cylinder. The primer at the base of the cartridge is struck by a falling firing pin or hammer when the trigger is released. The chamber then revolves to the next cartridge (indexing) on pulling back the hammer (single action) or by applying further pressure to the trigger (double action). The spent cartridge is accessed by rolling out the unlocked cylinder. The shells are then removed by pushing on the ejector rod, usually located under the barrel.

The *semiautomatic pistol* is now arguably the most popular handgun design. These firearms differ markedly from the revolvers. The cartridges are contained in magazines (usually concealed within the hand grip) and are held in place by a spring in the base. As each cartridge is fired, the spent cartridge is ejected and the next is fed up and into the breech.The force generated at the instant of discharge recocks the gun. All the shooter needs to do is squeeze the trigger repeatedly to allow the magazine to sequentially empty. The first round is fed into the breech by cocking the gun — in this case, pulling back and releasing the slide. From this point onward, the process is semiautomatic.

The true *automatic* or *machine* pistol takes this process one step further. The magazine may be emptied by sustained trigger pressure resulting in a rate of fire up to ten rounds per second. The automatic pistol is strictly a military issue weapon and is therefore not available commercially in sporting outlets.

Air pistols are often left out of the handgun classification. However, the gun laws in Australia regard air pistols as class H weapons. The pellets (usually of .177 cal) are propelled by compressed air or carbon dioxide. A full license is required to operate and discharge these guns. Furthermore, they are no longer available as toys for the casual shooter and all owners must be members of legitimate shooting clubs.

A detailed description of these weapons and related injury patterns is found later in this book.

LONG ARMS

Long arms can be divided into *rifles* and *smooth bore* weapons (shotguns). By definition, *rifles* have a gentle spiral groove cut into the bore of the barrel — so called lands and grooves. The projectile is slightly larger than the internal diameter of the bore and thus under great pressure, is forced into and between the lands and grooves, imparting a stabilizing gyroscopic spin during its flight.

The single shot rifles of today are either working antique pieces or faithful replicas. These weapons are black powder muzzle loaders. The powder (propellant), wadding, and projectile are sequentially placed into the muzzle and compacted with a wooden ram rod. These are often large bore weapons and are renowned for their accuracy, largely due to the relatively high projectile velocities and barrel length.

Many rifles carry magazines beneath the action. These magazines contain cartridges under spring pressure. The cartridges may be advanced into the *breech* by *bolt action*, *lever action* or *slide/pump action*. Each spent cartridge case is then ejected by opening the bolt, advancing the lever or activating the slide. Each discharge requires an independent trigger pull and activation of the advancing mechanism.

The *semiautomatic* rifle has essentially the same mechanism as described for its pistol counterpart. The inertia of a spring loaded action allows ejection of the spent shell, advancement of the next cartridge and firing in a single step, activated by a single trigger pull. The next step is again full automatic firing. This is achieved by continuous pressure on the trigger, thus allowing the magazine to empty rapidly. This weapon usually has an option for both semiautomatic or full automatic discharge.

Submachine guns are automatic weapons of lighter weight than machine guns. The magazines have a much greater capacity than standard semiautomatic weapons.

Machine guns can be hand held or can be mounted on supporting tripods or piers. The action mechanism is the same as the automatic weapon. The magazine may be long and curved or straight. Alternatively, the cartridges may be fed into the weapon on a flexible belt. The cartridges can be held and supported in a boxlike container on the side of the weapon. These weapons are capable of firing heavy caliber projectiles such as the 50 Browning and also specialized rounds such as armor piercing and tracer ordnance. Heavy caliber weapons are often mounted on vehicles, tanks, helicopters, and fixed wing aircraft.

Shotguns, as will be described later, frequently discharge multiple pellets or occasionally, specialized single solid slugs. These weapons have a smooth bore — that is to say, no rifling. The bore may be truly cylindrical (cylinder bore) or have a choke at the end. The choke is a very gentle taper at the end of the barrel designed to keep the discharged shot in a tighter aggregate over a longer distance. The degree of choke is specified as improved cylinder, modified, half choke, or full choke.

Shotguns may have either a single barrel or double barrel. Double barrel shotguns may be "over and under" or "side by side" in configuration. The gauge of the bore (the internal diameter) has an unusual historical derivation. The term refers to the number of lead balls, all fitting into the bore, that would make up one pound in weight. (i.e., 12 gauge equates to 12 lead balls collectively weighing one pound). Thus, there is a 10 gauge, 32 gauge, etc. The only exception is the .410 caliber which is 410 thousandths of an inch and therefore has the same rationale as the .22 or .303 caliber cartridge.

Traditionally, the shotgun is of break-open design. The breech is exposed as the lock and barrel hinge away from the stock (hence the term lock, stock, and barrel). The shotgun cartridge is then manually inserted into the breech and the lock engaged. The hammer is then pulled back (cocked) and the trigger is pulled. This causes the hammer to fall and discharge the cartridge. Opening the breech allows either manual extraction of the spent shell or the shell to fly out by an extractor mechanism.

Refinements led to the evolution of the bolt action, slide or pump action, lever action, and self- loading action as described for the rifled weapons. The slide or pump action (now illegal in Australia) is a common design. A number of shells can be contained in a cylindrical magazine underlugged to the barrel. Each action of the slide will advance a new cartridge and eject the spent one between trigger pulls.

HOMEMADE, IMPROVISED, AND MODIFIED WEAPONS

These illegal weapons vary markedly in design and are essentially limited by the imagination and ingenuity of the manufacturer. They range from crude cylinders with firing pins activated by simple trigger mechanisms and elastic bands to modifications of pre-existing starter guns or toys.

There may be a degree of cultural diversity in their design in that design and construction may be restricted to materials available to a particular country or village. Propellants may be commercial or home made.

Ammunition varies enormously, ranging from commercial cartridges and projectiles to crushed rock, glass, and metal fragments.

A more detailed description will be given in a specific chapter dealing with this diverse group.

FIGURE 1.1 REVOLVER

FIGURE 1.1 Major Components.

1. Hammer
2. Cylinder release
3. Grip
4. Trigger
5. Trigger guard
6. Cylinder
7. Ejector rod
8. Barrel
9. Muzzle
10. Front sight
11. Rear sight

FIGURE 1.2 Left above. Cylinder open

FIGURE 1.3 Left below. Cartridges in chamber

FIGURE 1.4 SEMIAUTOMATIC PISTOL

FIGURE 1.5 Semiautomatic pistol — slide retracted.

FIGURE 1.4 Major Components.

1. Rear sight
2. Hammer
3. Safety catch
4. Slide stop
5. Grip
6. Magazine
7. Trigger
8. Trigger guard
9. Muzzle
10. Front sight
11. Slide

FIGURE 1.6 RIFLE

FIGURE 1.7 Breech closed

FIGURE 1.6 Major Components.

1. Rear sight
2. Breech
3. Front sight
4. Muzzle
5. Stock
6. Magazine
7. Trigger and trigger guard
8. Bolt
9. Sling swivel
10. Butt plate
11. Magazine release
12. Head of stock

FIGURE 1.8 Breech open

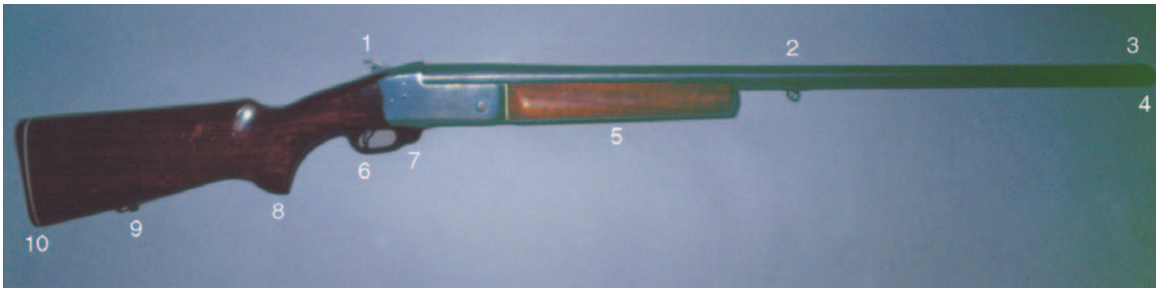


FIGURE 1.9 SHOTGUN

FIGURE 1.9 Major Components.

1. Hammer
2. Barrel
3. Front sight
4. Muzzle
5. Forend
6. Trigger guard and trigger
7. Breech lock
8. Pistol grip
9. Sling swivel
10. Butt plate

FIGURE 1.10 Break open position

FIGURE 1.11 Breech open

FIGURE 1.12 Cartridge *in situ*

ILLEGAL AND MODIFIED WEAPONS

FIGURE 1.13 An antique safety pistol (c.1910) that has been modified to accommodate a .22 short cartridge.The unmodified firearm was designed to fire blank cartridges only.

FIGURE 1.14 An example of a single barrel 12 gauge shotgun which has been modified to resemble a large pistol.This highly illegal modification is well represented in burglaries and homicides.

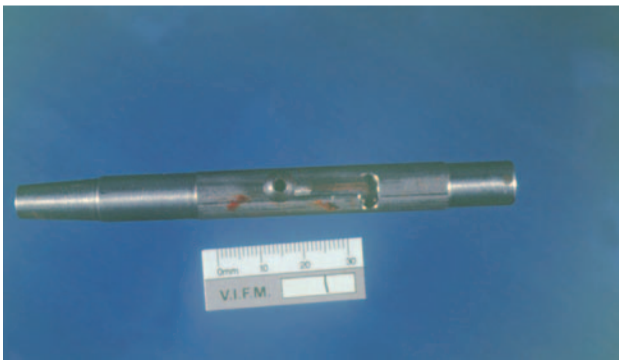


FIGURE 1.15 An example of a home made pen gun chambered to fire a .22 long rifle cartridge. This small weapon lacks accuracy over distance but is highly effective at contact or intermediate range.

2 Smooth Bore (Shotgun) Ammunition

A sound knowledge of the composition and components of the shotgun cartridge helps greatly in the interpretation of the many and varied injury patterns seen in forensic practice.

The shotgun shell has been in use since the mid 19th century and has changed little in basic design. The original shotgun cartridge cases consisted of a cylinder of tightly wound paper or drawn metal. The paper or cardboard shot shells later had a coating of lacquer to strengthen them and also to prevent water damage. The metallic shells could be reloaded many times before ultimate disposal.

The modern shot shell consists of a brass head, which contains the primer and supports the cylinder or cartridge case. The cylinder contains the propellant (immediately above the primer), the wadding (or plastic piston), and the projectiles. These components will be discussed in sequence.

THE BRASS HEAD

The brass head constitutes the base of the shot shell, contains the primer, and is in direct continuity with the cartridge case. Brass is still the traditional metal of use although brass-coated steel is often seen in modern cases. The base is stamped, showing the gauge (i.e., 12 indicating 12 gauge or bore) and the manufacturer's name. The base has a rim to allow extraction of the spent shell after discharge. The brass head may be either low or high (short or long) in design.

THE CARTRIDGE CASE

The cartridge case contains the powder, wadding or piston, and projectiles. Cardboard cases are still in use, although most modern shells use a high grade plastic that can be crimp sealed. Both cardboard and plastic shells can be reloaded. The outer surface displays the manufacturer's name, shot size, and often, the gauge.

THE PRIMER

The primer is a small metallic cup containing chemicals that detonate on impact with the striking hammer or firing pin. The cup may contain a small anvil that impacts on the explosive mixture. The design varies little from ammunition for centerfire pistols and rifles. The Boxer and Berdan designs are the most commonly used at present. At the moment of impact, the denotation takes place, releasing a small flash into the base of the shot shell that ignites the propellant.

THE PROPELLANT

The propellant traditionally was black powder (gun powder), but has now largely been replaced by modern "smokeless" powders. The propellant may be either flake, log, or ball type. (See chapter 6). The composition of the propellant varies with the manufacturer. All propellants tend to be slow burning to ensure that sufficient pressures are developed in the barrel to propel the projectile load.

THE WADDING AND PISTON

Early shot shells employed discs of cardboard (commonly called cards) or felt to separate the propellant from the projectiles and to secure the projectiles at the apex of the cylinder. The older design of shot shell is still in use and it is important to recognize the components as such and retrieve them from the depths of the wound at autopsy.

Modern shot shells now employ a plastic cup or piston to contain the projectiles. The base of the piston may be rigid or have an integrated pillar that acts as a shock absorber. In the 12 gauge shells, the piston is generally split into four leaflets that open after exit from the muzzle. The function of the piston is twofold:

(i) to contain the projectiles in a tight cluster until the instant of muzzle exit and
(ii) to reduce the degree of metal scouring of the internal surface of the barrel

The piston is aerodynamically unstable. On exit, it opens into a petal-like configuration that may be found 30 to 40 m. from the point of discharge. Again, it is vitally important to retrieve the piston or wadding from the depths of the wound as this provides a strong indicator of the distance of discharge to target.

THE PROJECTILES

The vast majority of projectiles constitute small round lead balls or lead-antimony alloy for added hardness, but steel shot pellets are also in use. The size of shot ranges from extremely fine (termed "dust shot") to larger balls such as 00 buckshot where nine balls are present per cartridge.

Larger balls are manufactured for use as a single projectile accommodating the caliber of the barrel and may contain an inert filler to take up the dead space between larger diameter projectiles. Single round lead balls of 12, 16, and 20 gauge are common. In addition, variants of the solid projectile are available for large game hunting, including the Brenneke, Foster, and Sabot slug. The first two of these single projectiles are rifled to impart a stabilizing spin while the last has a spool or Coke-bottle shape, not unlike that seen in air pistol pellets.

In some cases, the shot size follows a peculiar nomenclature, derived from the size of the target animal. Examples include L.G. (large goose), S.G. (small goose), special S.G. (special small goose), and S.S.G. (small small goose). The S.G. round is commonly used by police enforcement agencies and typically, the cartridge contains 9 round lead balls of 0.34 inch or 8.4 mm diameter (00 buckshot).

THE CAPPING

Older shells were capped by a disc of cardboard to seal the cartridge and prevent the loss of pellets. Many of these older cartridges also used wax as a final sealant. Modern cartridges have a crimped end that is in direct continuity with the cartridge case.

GENERAL COMMENTS

Recovery of a representative sample of shot is mandatory during the autopsy of a shotgun homicide victim.

The pellets tend to deform by a process of flattening or facetting, but generally do not fragment.

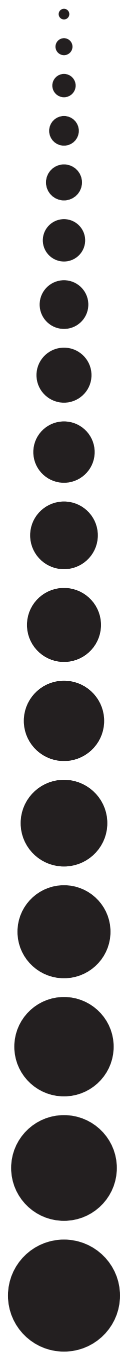
Weighing a representative sample will give a good indication of the size of shot fired if this is in doubt.

A pellet count can be performed on X-ray if all pellets are considered to have entered the body.

The wadding or plastic piston should be sought and retained. The piston design may assist in identification of the brand of manufacture and also in determination of the range of shot.

Again, it is emphasized that the gun in question should be test fired at set distances with comparable ammunition. Radiological studies of the body should be performed in all cases prior to autopsy.

All exhibits should be retained and sealed in a chain-of-custody transfer package.



Shot Size	Diameter (inches)
12 shot	0.05
9 shot	0.08
8 shot	0.09
7 shot	0.10
6 shot	0.11
5 shot	0.12
4 shot	0.13
3 shot	0.14
2 shot	0.15
1 shot	0.16
1 buckshot	0.30
0 buckshot	0.32
00 buckshot	0.34
410-g. round ball	0.38
20-g. round ball	0.545
16-g. round ball	0.610
12-g. round ball	0.645

FIGURE 2.1 Ordog, G.J., J. Wasserberger, and S. Balasubramaniam. (1988), "Shotgun wound ballistics," *The Journal of Trauma*. 28:5.

FIGURE 2.2 A selection of shot cartridges of varying gauge.

FIGURE 2.3 An opened shotgun cartridge of older design showing the brass head, propellant, over powder card, wadding, projectiles, and cap.

FIGURE 2.4 A modern 12 gauge shotgun shell.

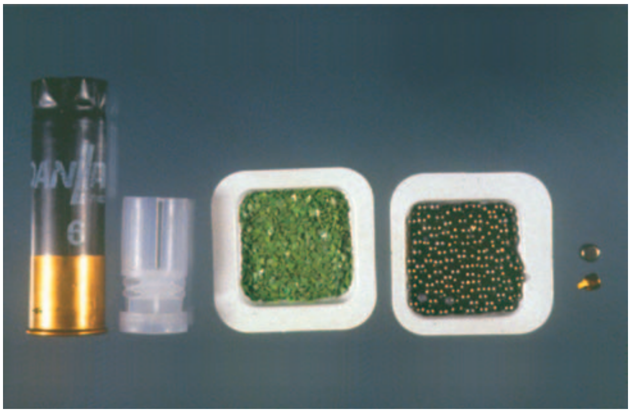


FIGURE 2.5 Shot shell opened and components separated. From left to right: brass head and cartridge case, plastic piston, propellant and shot (in tray), and primer assembly.

FIGURE 2.6 Base of brass head showing manufacturer's stamp, gauge and primer in situ.

FIGURE 2.7 Intact plastic piston.

FIGURE 2.8 Spent piston showing pellet indentation.

FIGURE 2.9 Primer components.

FIGURE 2.10 Cardboard wadding and capping as may be found in older style shells or in reload cases.

FIGURE 2.11 Opened shot shell showing piston (in situ), lead balls, and inert filter.

FIGURE 2.12 Recovered shot shell components from a homicide victim. Note wadding and deformed pellets.

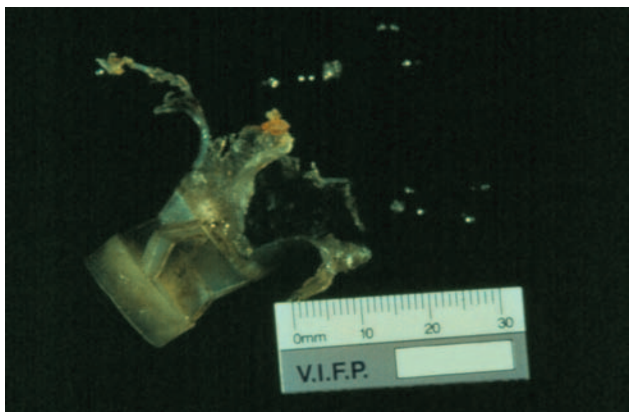


FIGURE 2.13 Recovered plastic piston and sample of lead shot. The shot in question was a hard contact discharge to the chest in a suicide.

FIGURE 2.14 Specialized shotgun projectiles. From left to right: the Brenneke, Foster, and Sabot slug.

FIGURE 2.15 The .410 cartridge. This caliber of shot shell may contain a plastic piston with three leaflets or conventional cardboard discs.

3 Handgun Ammunition

The previous chapter dealt with the types and components of shotgun cartridges. By comparison, the pistol bullet, which will be discussed in this chapter, is simple in design.

All bullets, whether they be fired from hand guns or rifles, possess essentially the same components: a primer, metallic cartridge case, propellant, and projectile. Only the .22 caliber bullet does not have a centrally located primer; this is termed a *rim fire* round and will be described separately. Having said this, the range of caliber and projectile design is such that many combinations can be generated, especially by the hand loader.

The components will be discussed in sequence.

THE CARTRIDGE CASE

The majority of cartridge cases have a cylindrical configuration although a small number may have a gradual taper or a bottle neck like design as may be seen in rifle rounds. Cartridge cases are generally made of brass.

The base of the cartridge is called the case head and most possess a head stamp, which is largely for identification purposes. The information usually includes the maker's name, caliber and perhaps other numbers or letters that indicate a date of manufacture or design.

Cartridge cases are classified into five distinctive types:

Rimmed
Semirimmed
Rimless
Belted
Rebated

Bullets designed for revolvers have a base plate that is wider than the cartridge case (semirimmed or rimmed) so they can be seated in the cylinder chamber. The spent shells are expelled manually by the ejector rod.

Rebated cases are used in semiautomatic and automatic weapons. The spent shells are expelled by an ejector engaging into the rebated groove.

THE PRIMER

The centerfire primer is essentially the same as used in shotgun shells.

Pistol primers come in two sizes, small and large. Again, the Boxer and Berdan primer designs are the most popular. The .22 rim fire cartridge differs from centerfire rounds in that there is no primer as such. The explosive compound lies at the base of the cartridge case and has been evenly dispersed by centrifugal force during manufacture. Commonly used chemicals include lead stynphate, antimony sulfide, and barium nitrate. These agents have superseded the rather corrosive and toxic compounds of the past such as fulminate of mercury. The compounds contained within the primer cup or at the base of the rim fire cartridge case detonate on percussion. The cost of production of these shells is minimal compared to centerfire cartridges, therefore the spent shells are not intended for reloading.

Gunshot residue detection is geared to the identification of the elemental constituents and this will be discussed in greater detail later.

THE PROPELLANT

Most propellants used in hand gun ammunition cartridge cases are fast burning and smokeless. As with rifle and shotgun rounds, the propellant can be milled as flakes, small logs, or balls. The range of propellants is vast and all have particular burning qualities that suit the individual's need. Since the barrel of the pistol is naturally shorter than that of the rifle, a sharper, quicker burn is required to create sufficient pressure to propel the bullet from the barrel. Propellant weight is measured by unit grain.

THE PROJECTILE

The caliber of the projectile for the most part is measured as a fraction of an inch. For example, the .357 caliber bullet is 357/1000 of an inch in diameter. Occasionally the nomenclature of the bullet incorporates the dimension and may be expressed in shorthand. An example of this would be the 25 ACP (.25 caliber automatic colt pistol). The 9 millimeter projectile is the exception.

Projectiles vary considerably in design as a quick glance in any manufacturer's catalogue will testify. Most bullets are composed of lead and, in many cases, the lead is hardened with antimony or tin. If the projectile is intended to travel at high speed through the barrel and suffer the trauma of engaging the lands and grooves, it frequently needs to be either toughened with additional metals (lead alloy) or have a protective outer layer of metal (a jacket). This is frequently termed gilding metal and is usually composed of a mixture of copper and tin.

The jacket may be complete (full metal jacket) or partial (semijacketed). The core of the jacketed projectile may also be composed of harder metals such as steel. (Softer metals such as lead or lead alloy may theoretically melt under the conditions of exceedingly high temperature and pressure at the time of discharge.) To protect the base of the bullet, a small metallic plate or cap called a gas check is employed. The gas check may dislodge and separate on impact with the target, as may the jacket.

In lower velocity rounds, a simple thin coating of copper or copper alloy is used. This is frequently seen in the .22 rim fire round. This process is also called gilding or the application of a copper wash.

As with propellants, the bullet weight is measured in unit grain.

Bullet Design

The basic bullet design can be simplified into four essential shapes:

round nosed bullet
semiwad cutter
wad cutter
hollow point

The semiwad cutter and full wad cutter are used extensively by the target shooting fraternity. The hole produced through the paper target is clearly defined and neatly punched out. Round nose bullets tend to create a less well defined perforation with bruised or crenated edges. Recreational shooters and enforcement agencies frequently prefer the standard round nosed or hollow point projectile. With the exception of the wad cutter, all other designs can be either fully or partially jacketed.

The softer metal of the bullet core may be exposed to allow rapid deformation of the projectile on impact. This will lead to greater expenditure of the bullet's kinetic energy and therefore greater local tissue disruption and destruction. To this end, a relatively recent projectile has been marketed by Winchester.

The *black talon* projectile is designed to peel back on impact and form small hooklets to maximise the surface area of the leading edge. There is no evidence to suggest that this projectile surpasses others of similar design for "stopping power." This projectile does, however, pose a potential health and safety risk for the forensic pathologist at the time of autopsy because the sharp hooklets may pierce the pathologist's gloved hand. The bullet is readily recognized on x–ray.

Radiological examination should always be performed before formal internal examination in all gunshot related cases.

Calibers in Common Use

.22 SR and LR (short rifle and long rifle)
.25 ACP[1]
.32 ACP
.32 S and W; S and W long[2]
9 mm.
.38 S and W
.38 special
.357 magnum
.44 magnum
.45 ACP

More formidable rounds include the .50 AE (action express), .45 Colt, and the 454 Casull.

1. ACP = Automatic Colt Pistol
2. S and W = Smith and Wesson

FIGURE 3.1 A collection of handgun ammunition, showing the great diversity of caliber and bullet design.

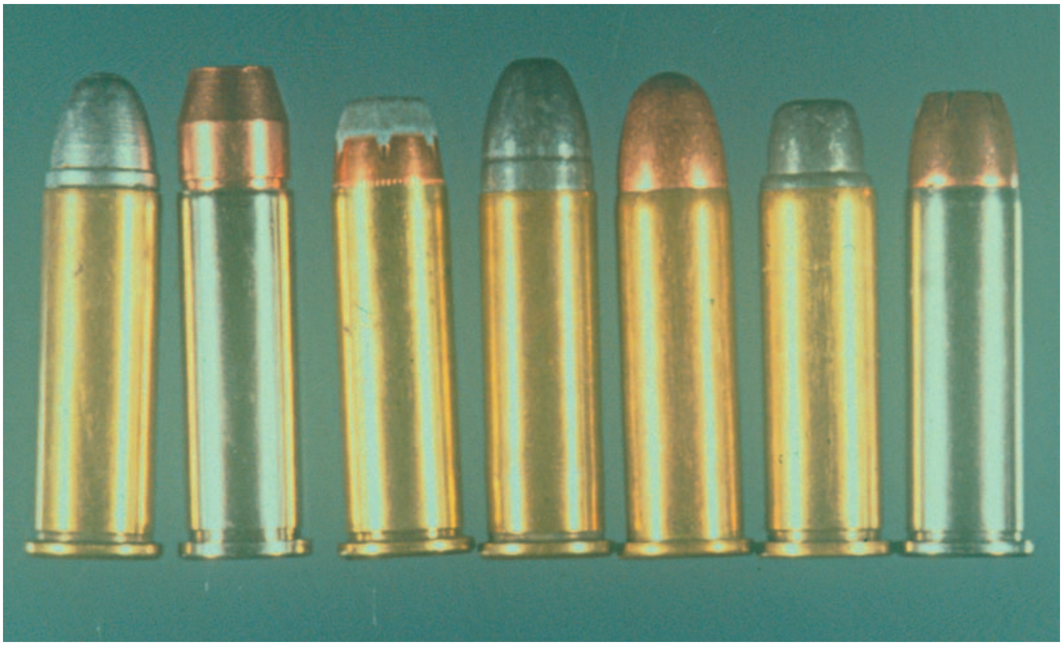


FIGURE 3.2 A collection of .38 caliber cartridges showing the diversity of projectile design.

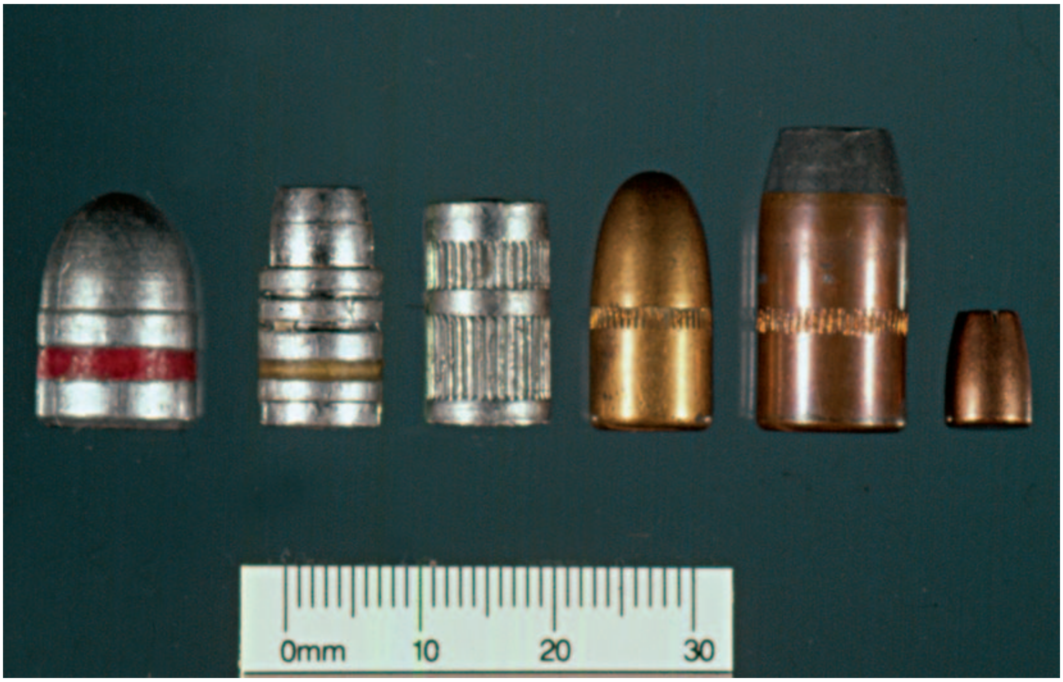


FIGURE 3.3 A selection of projectile types. From left to right: lead round nosed, lead semiwad cutter, wad cutter, full metal jacket round nosed, jacketed semiwad cutter, and jacketed hollow point.

FIGURE 3.4 The components of a typical 9 mm cartridge. From left to right: intact round, cartridge case, fully jacketed round nose projectile, primer cap, and propellant

FIGURE 3.5 Head stamp. The .50 AE showing the manufacturer's stamp and caliber.

FIGURE 3.6 Gas checks are metallic plates or cups that protect the base of the projectile from the intense thermal effects at the instant of discharge. A representative sample is shown here.

FIGURE 3.7 The 9 mm Winchester Black Talon cartridge. Note the peeling back of sharp metallic hooklets (talons) on the spent projectiles. This projectile poses a distinct safety risk to the forensic pathologist.

4 Centerfire Rifle Ammunition

The majority of centerfire rifle rounds are of high velocity type, which in this context indicates that the projectile travels at or greater than the speed of sound (1100 f/sec or 340 m/sec). As the bullet attains incredibly high speed during its passage through the barrel, the design must be markedly different from that of the standard lead projectile.

The centerfire rifle cartridge consists of a brass case, primer, propellant and the projectile. The primer is often of larger size compared to that used in pistol ammunition. As primers have been discussed previously and propellants will be overviewed later, only the casing and projectile will be outlined here.

Chapter 5 discusses the .22 rimfire cartridge. This round may be fired from either a pistol or rifle, and differs markedly from centerfire rounds in many respects.

THE CARTRIDGE CASE

By convention, the case is composed of the body (the main cylindrical component), the shoulder (the tapered component), the neck [which surrounds the "blunt end" of the projectile], and the mouth (the external junction of case and projectile).

The case for centerfire rifle rounds is generally made of brass, which is an alloy of approximately 70% copper and 30% zinc. Brass is an ideal metal for cartridge case construction because it has a high tensile strength sufficient to contain the high pressures generated at discharge, and its elasticity allows it to be drawn out into the desired shape to crimp and secure the projectiles.

The configuration of the majority of cases is the "bottle neck." Some have a gentle taper (conical); others have a truly cylindrical configuration.

The base plate contains the primer and the head stamp conveys information such as the caliber and manufacturer. In addition, other figures may be given that can be misconstrued as measurement data. A classic example is the .30-06 round. This indicates the caliber (.30 of an inch) and the year of model (1906). As with pistol rounds, the base plate may be rimmed, semirimmed, rimless, belted, or rebated. On cross section all cases have thicker walls towards the base plate, a design quality that reinforces the case against the enormous pressures generated at the instant of discharge.

The cartridge case undergoes a degree of expansion but this is contained within the solid chamber of the gun.

THE PROJECTILE

As most projectiles from centerfire rifles travel near to or in excess of the speed of sound, they must be protected from being literally torn apart by the rifling of the barrel. This would certainly occur if the projectile was made from soft lead or a lead alloy. To prevent this, the majority of centerfire projectiles are jacketed with gilding metal, which conveys a degree of hardness to the projectile during its short but traumatic journey through the gun barrel.

The projectile may have a full metal jacket (FMJ) or may be semijacketed. FMJ projectiles are traditionally military rounds while semijacketed projectiles are now considered hunting rounds. Occasionally, projectiles are manufactured from steel and again may be either fully or semijacketed.

The FMJ projectile tends not to deform greatly when passing through soft tissues and, therefore, is highly likely to exit the body. By contrast, the semijacketed or soft point projectile is designed to deform within the body and therefore expend much of its kinetic energy.

The degree of trauma seen after impact with high velocity rounds differs greatly from the .22 rimfire and most pistol rounds and these differences will be explained in later chapters outlining injury patterns.

The common bullet configurations are:

Round nosed
Spitzer
Boat tail

All can be fully jacketed or semijacketed.The so called "soft point" can also be hollow point in design as is seen commonly in pistol projectiles.

As opposed to the pistol round, there are in excess of 800 distinct types of centerfire rifle bullets and, in addition to the ammunition manufactured by companies such as Winchester and Remington, there are many companies whose sole purpose is to produce projectiles. A quick glance through a catalogue from companies such as Hornady and Sierra instantly conveys the vastness of the range of projectiles that are available on the market today. The differences lie in caliber, case conformation, and projectile design and in addition, these standard projectiles may be modified over time. Many owe their origins to military use, others are now employed as hunting rounds.

The reader is referred to such classic texts as *Cartridges of the World* by Barnes and McPherson (1997; see key texts for a more definitive list).

Calibers in Common Use

17 Remington
22 Hornet
225 Winchester
22-250 Remington
244 Remington
270 Winchester
7 mm Mauser
30 Carbine
300 Savage
308 Winchester
30-06 Springfield
303 British
30-30 Winchester
338 Winchester magnum
348 Winchester
375 Winchester
444 Marlin
45-70 Government

It is reasonable to say that no defined nomenclature actually exists and one must therefore refer to authoritative texts for definitive data.

FIGURE 4.1 A collection of centerfire rifle ammunition. Note diversity of both cartridge size and projectile design.

FIGURE 4.2 A typical centerfire round. .308 caliber cartridge with a soft point Spitzer projectile.

1. Mouth
2. Neck
3. Shoulder
4. Body
5. Base Plate (containing Primer)

FIGURE 4.3 The components of a typical centerfire round. The .303 British. Note cartridge case, primer, flash hole, propellant, and projectile.

FIGURE 4.4 A selection of projectiles. From left to right: (military) round nosed, Spitzer and Boat tail (hunting), round nosed soft point, Spitzer soft point, semipointed soft point, Spitzer hollow point, and semijacketed hollow point.

5 The .22 Rimfire

The .22 rimfire cartridge is without doubt the world's most popular round as used by recreational shooters and has been in constant production for more than 100 years. Almost anyone who has fired a rifle, whether on a farm, for small game hunting, or for "plinking," has fired a .22 rimfire. Production costs are minimal and the final product is affordable, ranging from three to eight dollars (AUS) per 50 rounds. The size of this little bullet, however, belies its potency. Because it is sufficiently different from the centerfire cartridge intended for rifle and pistol use, the .22 rimfire has also earned its own chapter both here and later in the discussion of specific injury patterns.

As a direct consequence of its widespread use, this cartridge is implicated in many cases of homicide, suicide, and accidental shooting. For this reason, a basic understanding of the design, specifics, and components of the cartridge is highly desirable.

The .22 rimfire is produced as a short cased cartridge (.22 short), long case with .22 short type projectile (.22 long), long case with a slightly longer projectile (.22 long rifle), .22 long rifle with hollow point projectile (often called a "stinger"), and the .22 rimfire Magnum round.

The .22 short and long rifle cartridges are equally suited for both rifle and pistol shooters. The former is a popular round for competition pistol shooters in events such as the "rapid fire." The small payload of this particular cartridge reduces the recoil of the pistol to an absolute minimum. The .22 short, depending on payload, can achieve high velocity and has an extreme range of approximately one mile.

The hollow point projectile (or stinger) weighs 30 grain and has the same payload as the long rifle round, thus increasing its muzzle velocity by some 30%. These rounds are often referred to as hypervelocity .22s.

The .22 magnum round was introduced by Winchester in 1959. The cartridge case is longer than the .22 long rifle round. This round may also be fired from both rifle and pistol, although, in the case of the latter, the revolver needs to be rated accordingly to accommodate the extra power of the discharge.

The projectile may be fully jacketed or of jacketed hollow point configuration.

THE CARTRIDGE CASE

The casing or shell is usually made of brass or may be nickel plated; its case configuration is cylindrical. The base is flat, rimmed, and carries only the manufacturer's stamp. Neither the case and nor the head stamp carry any indication of the caliber of the bullet.

THE PROJECTILE

The .22 rimfire bullet is generally made of solid lead and weighs 40 grain. The hollow point projectile weighs between 35 and 38 grain. The projectile may have an anodized copper wash and is frequently wax lubricated. Typically, the body of the bullet carries a circumferential etched knife mark and several cannelures.

The .22 short projectile weighs 29 grain and has a similar external appearance to the long rifle projectile.

The magnum round may be either fully jacketed or of hollow point configuration.

THE PRIMER

The .22 cartridge is rimfire by design. This term indicates that there is no centrally located metallic primer component within the base of the casing. The striking action of the firing pin onto the edge of the base initiates the detonation, ultimately leading to ignition of the propellant.

The primer compound is evenly distributed by centrifugal force and dispersed over the floor of the casing during manufacture. Many companies produce this projectile and at least 70 types of .22 caliber ammunition are available. For this reason, the constituents of both primer and propellant vary enormously.

As in many other rifle and pistol rounds, the primer is often comprised of explosives such as lead styphnate, silver azide, mercury fulminate, and nitro compounds like trinitrotoluene. These explosives may be mixed with additional substances such as antimony sulfide (stibnite) or calcium silicide, which act as fuel.

To ensure a rapid combustion, an oxidizer such as barium nitrate, potassium chlorate, lead dioxide, or lead nitrate is occasionally added. In addition, fractionators, sensitizers, and binders may be added.

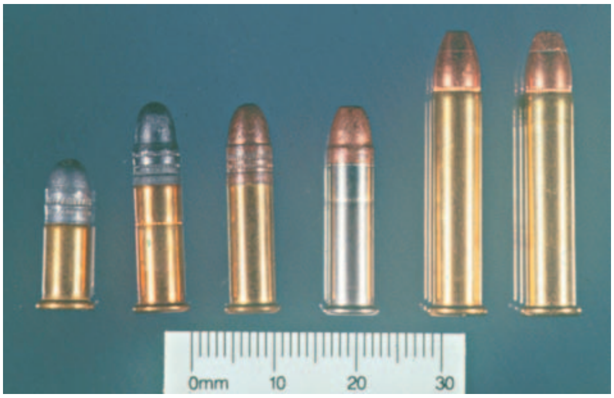


FIGURE 5.1 The .22 rimfire family from left to right:
.22 Short
.22 Long
.22 Long rifle
.22 "Stinger"
22 Magnum (with FMJ and hollow point projectiles).

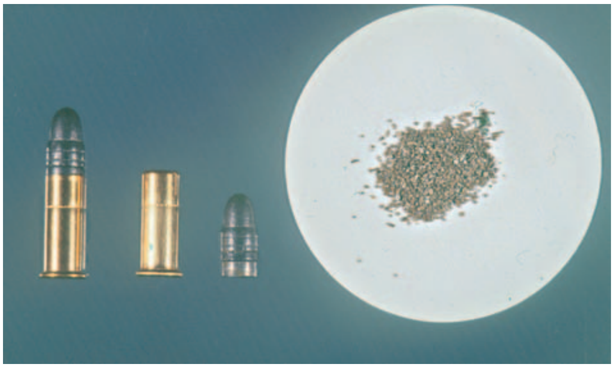


FIGURE 5.2 The components of a typical .22 rimfire round. From left to right: intact round, cartridge case, round nosed lead projectile, and propellant.

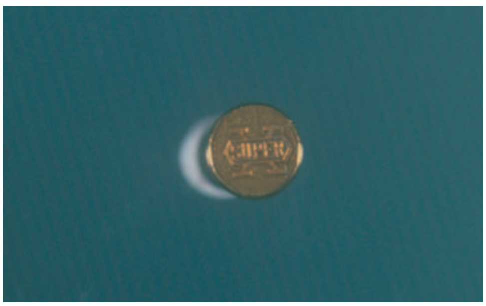


FIGURE 5.3 The head stamp of a typical .22 rimfire round. Note the absence of a centrally located primer.

6 Propellants

The forensic pathologist may question the need for a section on propellants, but the compounding of propellants may have a bearing on injury patterns in cases of intermediate range fire. For this reason alone, a dedicated section is fully justified.

Propellants can be divided into two subtypes — black powder (traditional gun powder) and smokeless powder.

GUN POWDER (BLACK POWDER)

Black powder, by its very nature, is a true explosive. The smallest of sparks is sufficient to effect ignition. On ignition, a large quantity of bluish-grey smoke is generated and a characteristic sulfurous residue is deposited on both the weapon and the shooting hand.

It was first used as a propellant for firearms in the early 14th century and is thought to have originated as early as the 11th century. The Chinese are credited with its discovery and the discovery of the explosive properties of the mixture of substances we know as traditional gun powder — sulfur, charcoal, and saltpeter (potassium nitrate). It is suggested that gun powder may have been used in the manufacture of fireworks well before its application to firearms and warfare.

Black powder is still in use today. It is employed as the explosive component in fireworks and as the propellant in black powder firearms. Black powder firearms are now used almost exclusively by amateur enthusiasts and within certain factions of pistol and rifle clubs. Injuries from black powder weapons are uncommon but are well documented.

Only the manufacturing process has been refined over time. The final product is usually manufactured as an extremely fine, black dustlike substance or a delicate microspherical particle such as FFFg. It is this fine compounding that makes gun powder somewhat hazardous to use. Because it is extremely finely divided, it has a habit of coating surfaces and is therefore predisposed to inadvertent ignition from sparks, or from lit ash, such as from cigarettes or pipes.

SMOKELESS POWDERS

Smokeless powders have been in general recreational use since 1884 and are relatively difficult to ignite in the unconfined environment when compared to the dramatic effects of ignition of traditional black powder. On ignition, they generate some smoke but not to the extent of black powder. Smokeless powders are all basically compounded from nitrocellulose or "gun cotton," a compound that is is relatively stable, easy to handle, and less likely to inadvertently ignite.

If nitrocellulose is the sole energy source, then the product is termed a *single based (SB)* propellant. The *SB* powders are chemically more stable over time.

If nitroglycerine is added to increase the energy content, the product is termed a *double based (DB)* propellant. This group constitutes the vast majority of proprietary propellants available for the recreational shooter. The *DB* compounds are nonhydroscopic.

Both types, *SB* or *DB,* can be milled as flakes, small logs, or spheres. It is the geometric configuration of the powder that has the most influence on injury pattern at intermediate range. The configuration of the powder also tends to dictate the rate of burn. The fine flakes often affect a near complete burn, while the sturdier log or spherical designed product may be expelled as unburnt, burning, or burned particles that can truly abrade the skin on impact. The effect is not unlike the impact of sand grains on skin at high speed. This phenomenon is commonly termed *stippling* or *tattooing* and the impact effect on the skin cannot be wiped away at post mortem. The observation of stippling or tattooing is of the utmost importance in range determination as will be seen in the next chapter.

The configuration of the powder tends to dictate the rate of burn. This is directly related to the external surface area exposed within the cartridge case at the instant of ignition. The thin flake is usually of *fast burn* type, whereas the solid log type requires more time to fully combust and is therefore deemed to be of *slow burn* type.

The Du Pont Powder Company produces a propellant that is truly cylindrical. These loglike particles have a central cavity through their long axis, which greatly increases the exposed surface area available for rapid combustion.

The ball type product is a *medium burn* powder, as all spherical powders burn evenly from the outside in. By flattening the ball particle into a small disc, the rate of burn increases, again reflecting the function of exposed surface area.

Some brands of powder incorporate colored flakes as a means of identification. These may be of use to the ballistics expert at the crime scene, or later in the laboratory after close examination of clothing items.

For the reader who demands greater detail on the qualities and specifics of propellants, I unreservedly recommend the book *Propellant Profiles* (1999) by David Wolfe. This compendium details the composition, physical properties, and applications of in excess of 130 proprietary powders. In addition, this excellent reference provides data for hand loaders with correlates of bullet caliber, optimal load (in grains), and resultant velocities.

A representative collection of commercially available propellants

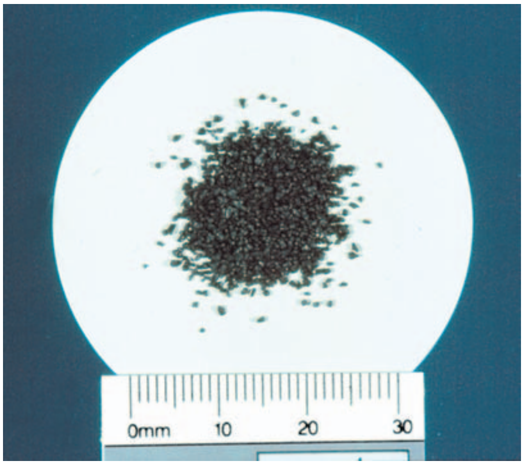


FIGURE 6.1 Traditional black powder FFFg.

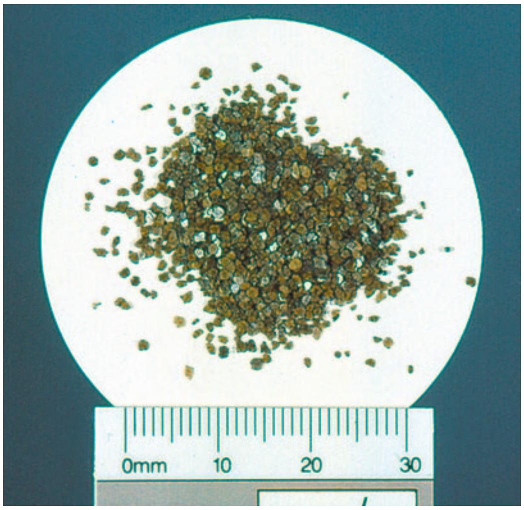


FIGURE 6.2 Flake.

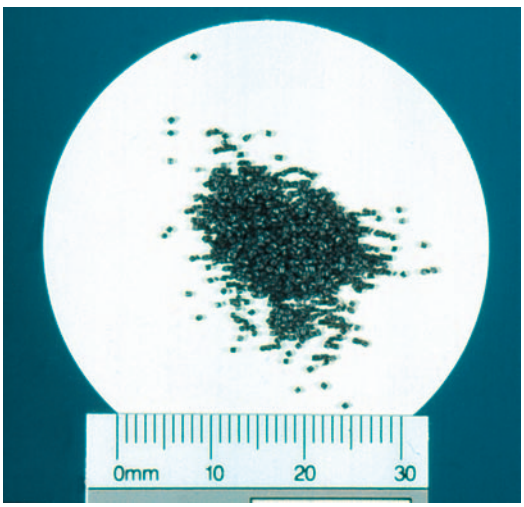


FIGURE 6.3 Ball type.

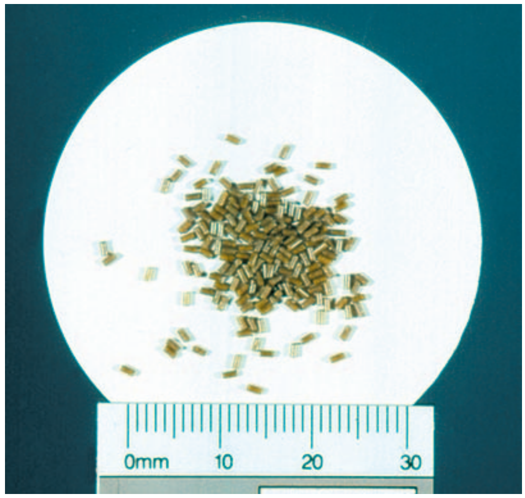


FIGURE 6.4 Log.

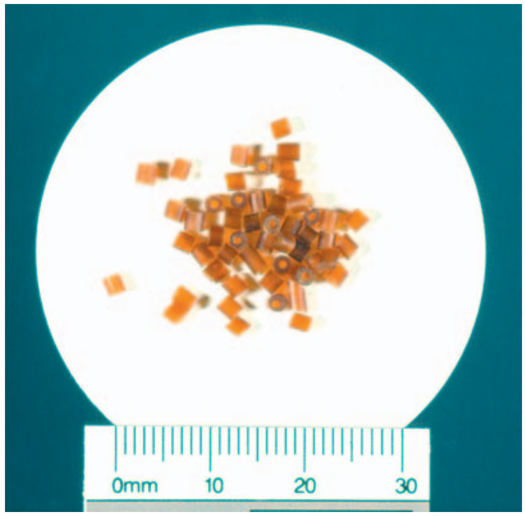


FIGURE 6.5 Hollow log.

Part B

Injury Patterns

7 "Pathological" Range of Fire

The accurate determination of the range of fire (that is to say, the distance from the muzzle to the body at the instant of discharge) may pose many problems for the forensic pathologist.

Crime scene and police agencies need to ascertain several key points during the investigation of deaths involving firearms. These points include:

1. The type of weapon involved (rifled or smooth bore)
2. The type and caliber of ammunition used
3. The number of shots fired
4. The direction/angle of the shots

The pathologist, while also actively involved in determining the above, is further expected to supply accurate information in his report pertaining to:

1. The range of fire
2. Confirmation of the direction of fire
3. Internal organ damage
4. A comment of capability of defense or response on behalf of the victim

The concept of determination of the range of fire is arguably the most difficult. It is not uncommon for this information to be contested in a court of law and may be pivotal to the outcome of a case.

The term "pathological" range of fire may seem to be initially somewhat confusing. The forensic pathologist is more or less bound to categorize the range of fire based on a set of predetermined parameters. The presence or absence of certain features of the gunshot wound either include or exclude it from one of the three categories that follow. The most workable classifications for injuries caused by rifled weapons are:

1. *Contact* (hard contact, contact, and near contact)
2. *Intermediate*
3. *Distant*

Indeterminate remains an option for the entry wound that cannot be categorized with confidence.

At the instant of discharge, many constituents of the cartridge and products of combustion are expelled under great pressure. These include:

1. The projectile
2. Vaporized projectile or casing fragments
3. A large volume of gas under great pressure
4. Soot and flame
5. Burnt, burning, and unburnt propellant
6. Primer constituents

If smooth bore weapons are considered, then we can include:

7. Multiple pellets (in lieu of a single projectile)
8. Felt or cardboard wadding (cards) or plastic piston
9. Inert filler

Many books and chapters describing firearm wound interpretation tend not to apply the concept of contact, intermediate, and distant range shots to shotgun trauma. Rather, terms such as close discharge, short to mid range, and mid to distant range are offered. Problems arise in the interpretation because of the complex trauma caused by multiple pellets flying in a tight or emerging aggregate, effects of thermal trauma, sooting, and the particular injuries caused by the impact of the petal or piston against the skin.

Fortunately, the shotgun lends itself to the procedure of test firing. Test firing allows accurate reproduction of pellet dispersal over distance, provided that the same gun (with same choke) and the same ammunition are used under controlled conditions.

Contact and distant range injury from shotguns are relatively easy to categorize. Most authoritative texts include tattooing and injuries from the piston in the intermediate category.

The machinations of shotgun injury will be dealt with in greater detail in a later chapter.

A point that cannot be overemphasized is the factor of overlying clothing modifying the injury patterns. In a hypothetical scenario, 50 people witness a man shoot another with a .38 caliber revolver at close range — say one to two feet. If the skin is fully exposed to the shot, one may expect some deposition of unburnt powder (stippling or tattooing). This wound description would automatically place the shot at intermediate range. If, however, the victim is noted to be wearing a heavy leather coat, jumper, shirt, and singlet, then the bullet entry wound will resemble a distant range shot — hence the term "pathological."

Naturally, all clothing needs to be examined by the forensic scientists, but this will not alter "the call" of the pathologist.

Evidential information pertaining to clothing will no doubt be brought out during the committal or trial and the onus is on the pathologist to explain (often at length) the modifying effects of clothing. Indeed, a light item of clothing such as a T-shirt would be sufficient to protect the skin from the peppering effects of unburnt powder particles. Having said this, let's consider the factors that determine the categories of range of fire.

CONTACT RANGE

Contact range implies that the muzzle of the gun is placed against, or very near to, the skin of the victim at the instant of discharge. If the muzzle is placed sufficiently firmly against the skin surface as to impart an indentation or bruise/abrasion (muzzle imprint), then the term *hard contact* is used. As the muzzle effectively seals the bore of the gun against the skin, little, if any, gas escapes externally.

The classic wound will show the external diameter of the muzzle (perhaps also the front sight) with a concentric round defect representing the point of bullet entry. Close inspection generally shows blackening from flame and soot into the depths of the wound. Later dissection (aided by magnification) will confirm the presence of expelled combustion products into subjacent tissues.

Remember that bullets are essentially blunt objects travelling at high speed, and push their way into tissue. These injuries are, therefore, lacerations.

The edges of the entry defect may be abraded. This circular band of roughening is frequently termed the *abrasion rim*.

The bullet may accumulate grease, grime, and fine lead dust from the lands and grooves of the bore and these can be wiped onto and into the entry wound. This is called the *grease rim*.

As the seal is often imperfect, a small amount of gas and soot may escape either radially or eccentrically. *Tattooing* or *stippling* (a vital reaction to the effect of unburnt powder abrading the skin) will not be seen.

In some cases, carbon monoxide under great pressure may be deposited and absorbed into regional muscle. This phenomenon is perhaps best seen after shotgun discharges where the volumes of gas expelled are far greater than those seen after the discharge from a rifled weapon. The muscle tissue, often extensively shredded, may appear bright pink-red, representing the formation of carboxyhemoglobin.

Often the wound is not a perfect circle and first inspection may reveal a wound that could be confused with an exit. In cases of hard or near contact against skin with deep tethered bone (such as the scalp), the entry may be ragged, irregular, or frankly stellate in configuration. This phenomenon is readily explained by rapid expansion of gas into the subcutaneous soft tissues, literally blowing and stripping the soft tissues away from the bone.

The *contact* (nonspecific) entry wound implies that the muzzle is placed against, but not hard against, the skin. This allows some limited concentric dispersal of soot onto the skin, creating a small, densely blackened circular area surrounding the entry defect. The soot deposition may be eccentric if the muzzle is placed any way other than truly perpendicular.

The term *near contact* implies that the muzzle is in close proximity to the skin, usually in the order of one to two centimeters. The sooty concentric zone will be wider in diameter and exceed the external diameter of the muzzle by up to three to four times. Both the abrasion and grease rims may still be present, but may be obscured by overlying soot. At the moment of discharge, combustion products are expelled in a conical distribution.

If the shot is fired in close proximity to the hair-bearing scalp, it is not uncommon to see the hair shafts being somewhat "fluffed up" and close inspection may reveal finely dispersed soot particles among the hair follicles. This phenomenon may be readily overlooked in darker haired persons.

INTERMEDIATE RANGE

This category strongly indicates that the muzzle of the gun was some distance from the skin.

The hallmark of the intermediate range shot is the formation of *tattooing* or *stippling*. Tattooing is a vital reaction caused by unburnt powder fragments abrading the skin of the living person.

Fine blood spatter may resemble tattooing at first glance; however, tattooing cannot be rubbed off the skin and is a permanent feature at autopsy. Classic tattooing is seen as fine to coarse peppering of the skin with a condensation or concentration of the peppering surrounding the entry defect.

The color of tattooing ranges from red-brown to orange. Examination under magnification may indeed disclose adherent and embedded propellant particles.

The configuration of the propellant granules often aids in the formation of tattooing. For example, fine powder and flakelike granules frequently undergo complete or near complete combustion and are less likely to cause tattooing. However, coarse powder particles (such as the spherical or log configuration) tend to burn incompletely and therefore leave sufficient solid material to impact against the skin at high velocity.

In the case of revolvers and semiautomatic pistols, the "rule of thumb" suggests that tattooing should not be expected much beyond a distance of two to three times that of the barrel length.

The data is less distinct in cases of discharges from long arms such as shotguns and rifles. In fact, many texts indicate that beyond three feet, tattooing is highly unlikely. Central to the zone of greatest condensation of tattooing, the abrasion and grease rims may still be expected to be seen.

The effect of naked flame and frank thermal injury should not be a feature.

DISTANT RANGE

This injury type is the least complicated because the distant range injury constitutes the bullet hole only. The bullet may enter through the skin sideways, backwards, or at any angle.

There is no stippling or tattooing and certainly no soot deposition or thermal effect. Bear in mind that this pattern of injury may be seen from several feet or up to a mile or more, depending on ammunition type and velocity. An abrasion rim may still be seen although the true circular edge as seen in closer range shots may be lost over long distances. As the bullet travels through space, it gradually loses momentum and the aerodynamic spin that imparts stability. In short, the bullet begins to tumble in space. A grease rim may still be seen in some cases.

Low velocity v. high velocity

A comment may be given regarding the velocity of the projectile at the time of impact. Allowing for a true perpendicular impact, all things being equal, a low velocity projectile creates a neat hole through the skin and in most cases, a well defined abrasion rim is seen. By comparison, the high velocity projectile may frequently create a hole with radiating splitting edges.

This is a function of the preceding shock wave generated at supersonic speeds. For this reason, the entry wound may be confused with that of an exit. The production of an abrasion rim is variable.

Massive explosive disruption frequently occurs in cases of shotgun, high velocity rifle, and heavy caliber handgun discharges, particularly when the muzzle is placed against the side of the head or into the mouth. Much of this destructive force is directly due to the rapid expansion of gases in tandem with the passage of the projectile. Radiological examination may frequently clarify the situation.

The so called "lead snow storm" is often seen in high velocity rounds; this phenomenon will be discussed later in chapter 23.

KEY POINTS

1. Always consider the modifying effects of overlying clothing. All clothing items should be examined by the forensic scientist for soot deposition and unburnt powder particles.
2. The body should never be stripped prior to examination by the forensic pathologist.
3. All implicated weapons should be test fired under controlled conditions. An independent report should be sought from the ballistics department.
4. The concept of "range of fire" depends on the presence or absence of certain features.

If in doubt, the term "indeterminate" should be considered, and an appropriate comment made in the final report.

A B

FIGURE 7.1 Hard contact range discharge. This photograph clearly depicts the circular abrasion of the muzzle of a semiautomatic 9 mm pistol. Soft tissue protrudes through the central defect. The inner wound edge shows prominent blackening. There is little radial venting of soot — a testimony to the firm application of the muzzle.

FIGURE 7.2 Hard contact discharge against tethered skin. A classic stellate splitting radial complex of lacerations is demonstrated. This is due to rapid gas expansion and tearing of soft tissues away from the skull at the instant of discharge. Once reconstructed, the faithful representation of the muzzle imprint is seen. Note blackening of the wound edges — .38 Special.

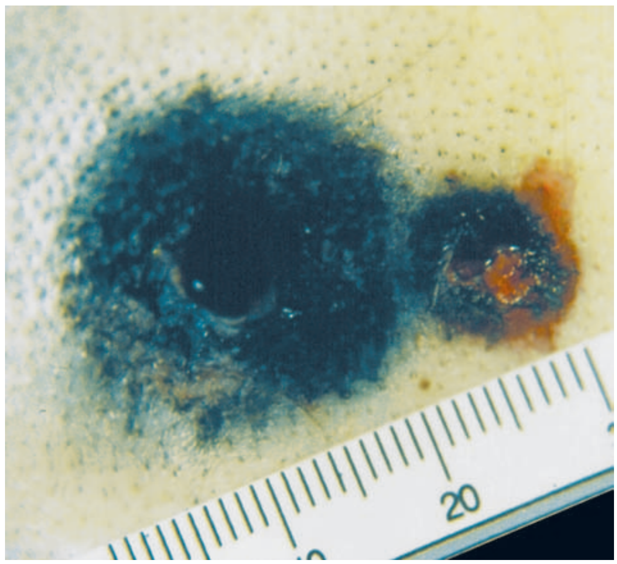


FIGURE 7.3 Near contact and contact range discharge. This photograph demonstrates a near contact (left) and contact (right) entry wound to the temple. The contact wound shows circumferential blackening approximating the diameter of the muzzle — no distinct muzzle imprint is seen. The near contact entry wound shows a perfectly circular but wider sooty area, representing a distinct but short distance from muzzle to skin. .38 Special revolver.

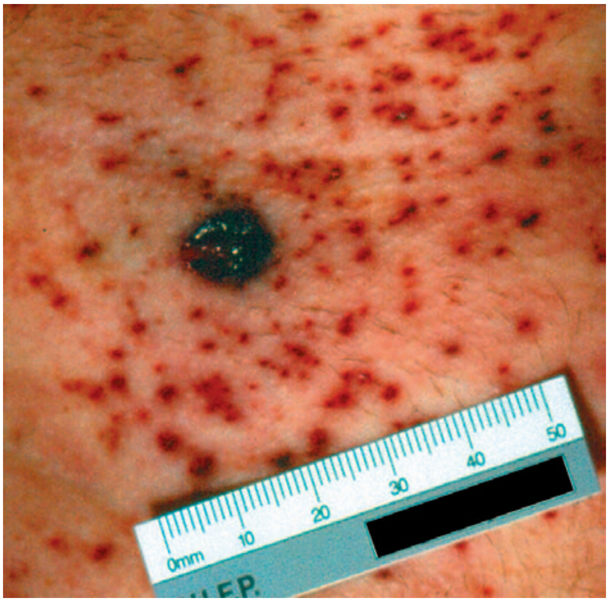


FIGURE 7.4 Intermediate range discharge. This image shows the classic tattooing or stippling seen in intermediate range shots. The weapon in question was a .38 Special revolver. Note the central blackened and abraded circular defect and the dispersal of fine punctate abrasions caused by the impact of unburnt propellant fragments against the skin. This is the defining feature of the intermediate range shot.

FIGURE 7.5 Distant range discharge. The defect is nondescript and is slightly wider in diameter than the fired .38 Special projectile. The dimension of the wound may be reduced in size secondary to skin elasticity. Note the presence of some radial splitting. The abrasion rim is poorly developed. The apparent focal blackening is due to overlying dried blood. The distant range shot is typified by complete absence of tattooing and thermal effect.

8 The .22 Rimfire Projectile

The .22 caliber long rifle (LR) cartridge is without doubt the worlds's most popular round, and for this reason, it is commonly seen in cases of accidental shooting, suicide, and homicide. The solid lead projectile of the .22 LR weighs 40 grain and may attain a muzzle velocity of up to 350 m/s. Higher velocities may be seen with magnum and "stinger" rounds, traveling at 610 and 515 m/s respectively.

The .22 short (as mentioned previously in chapter 5) can also attain high velocities and is often underestimated in regard to both power and accuracy. The powder payload, in comparison to center fire rounds, is quite small. For this reason, there is often little sooting and flame effect in contact range discharges.

Many variables exist, including the firmness of application of the muzzle to the skin, the regional anatomy, and the propellant payload.

CONTACT RANGE SHOTS

This category includes hard contact, contact, and near contact discharges.

The skin defect in "hard contact" range discharges is more often than not circular and well defined. If the skin is tightly bound down to bone then classically, the wound edge may exhibit small to medium sized radial splitting lacerations. Lacerations exceeding 10 mm in length are infrequent. Close inspection is more likely to show small (2 to 3 mm) radiating lacerations around the circumference of the wound. These fine lacerations may well be concealed by adherent blood or overlying soot and thermal effect.

The presence of a muzzle imprint is quite variable, even in the confirmed hard contact discharge. If the muzzle is held tightly against the skin, the imprint of the muzzle is frequently imperfect, blurred, or incomplete and is better seen in cases of revolver or semiautomatic pistol discharge where the gun may be handled with greater stability.

The mechanism of holding a rifle to the head in a perpendicular position is often quite tenuous, frequently leading to incomplete muzzle seal and tangential venting of soot and flame. The presence of a slightly ovoid full thickness defect with an eccentric ellipse of sooting is commonplace.

Contact and *near contact* wounds are frequently circular, with dimensions closely approximating the diameter of the projectile. However, it should be noted that skin elasticity may greatly modify the appearance of the wound. The author has seen a 10 mm diameter defect produced from a hard contact .22 discharge.

In contact and near contact wounds, the wound edges are generally blackened. The abrasion rim is often well demarcated and the grease rim is frequently well represented. The circular penetrating defects through the skull range from neat uncomplicated holes (as is frequently seen in the .22 short discharge) to slightly wider holes with complex radiating fractures (as may be seen in the .22 LR and Magnum rounds).

With the exception of the Magnum round, almost all standard .22 LR projectiles tend not to exit the head but very often come to rest beneath the contralateral inner table or between skull and overlying scalp. Often the bullet is palpable beneath the scalp and may literally fall out and on to the surface of the post mortem table at the moment of reflecting the scalp. The .22 short and LR rounds also have the reputation of internal ricochet within the cranium, further creating complex injury patterns.

If the muzzle is placed against the squamous temporal bone, then the standard .22 LR may well exit, particularly in cases of younger victims.

In the majority of cases, unburnt powder is seen between skull and scalp, diploe, and within the depths of the wound. In exceptional cases, unburnt powder particles may be seen in the exit wound.

INTERMEDIATE RANGE SHOTS

The dispersal and intensity of tattooing is far less than may be expected for centerfire cartridge discharges. This observation reflects the smaller quantity of propellant and also the conformation of the propellant particles. In the case of rifle discharge, much of the propellant has been completely burnt, leaving few unburnt particles to impact against the skin and thus cause tattooing. The pattern of the tattooing is generally more evenly dispersed and often lacks the classic concentration surrounding the central bullet entry wound. Tattooing or stippling is much more likely in cases where the propellant is milled as a ball type. Close inspection may reveal adherent particles of powder on the skin.

DISTANT RANGE SHOTS

The entry defect at distant range is nondescript. The hole may be round, ovoid, or frankly irregular. The abrasion rim is frequently well defined but may be irregular in contour. There is also the tendency to form small radial splits. This latter phenomenon probably represents the tendency of the projectile to tumble and impact against the skin at odd angles.

When retrieved at autopsy, the .22 caliber projectile is frequently found to be profoundly deformed and is mushroom shaped, with relatively good preservation of the base of the bullet. In other cases, the bullet may fragment into three or four large pieces and produce many more fine particles, which can only be detected at the radiological level.

The solitary distant range shot may be confused with a puncture wound from a tapered instrument such as an ice pick, stiletto, or screwdriver. This reinforces the point that all cases should be X-rayed if stabbing or gunshot are suspected.

The following images provide a general representation of the injury patterns sustained after impact with a .22 rimfire projectile.

FIGURE 8.1A Contact range shot to mid forehead in a case of suicide. .22 short. Note the well defined circular defect with microsplitting at the edges, blackening and abrasion rim.

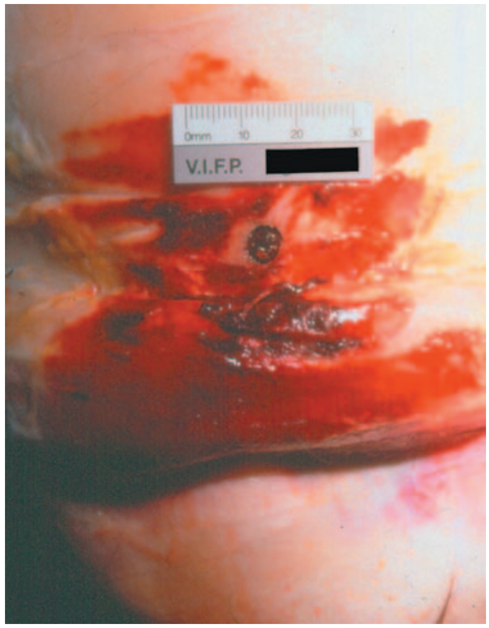


FIGURE 8.1B The scalp has been reflected. The cranial defect is circular and approximates the diameter of the bullet. There is no evidence of radial fracture in this case.

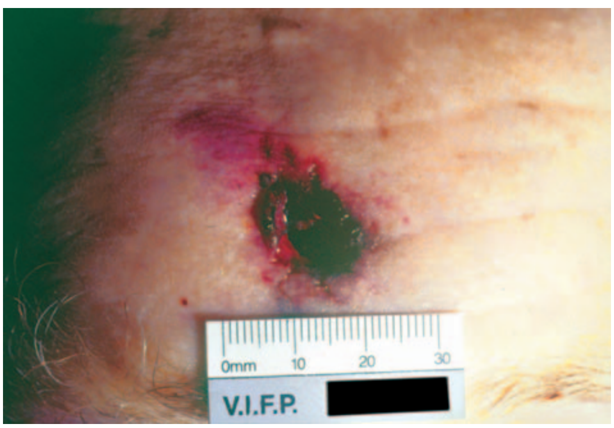


FIGURE 8.2 Hard contact discharge to mid forehead. .22 LR. The defect is slightly ovoid. Radial splitting lacerations are present.

FIGURE 8.3A Hard contact discharge to mid forehead in a case of suicide. .22 LR. Well defined radial splitting lacerations are demonstrated, and in this case, the muzzle imprint is clearly outlined.

FIGURE 8.4 Hard contact discharge to the temple in a case of suicide. .22 LR. Note incomplete muzzle imprint. The front sight is represented. There is no external soot deposition.

FIGURE 8.3B Close view. Unburnt powder is clearly seen on the outer table of the skull and within the diploe.

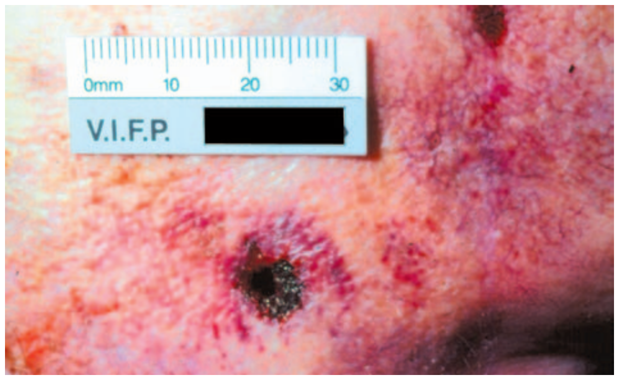


FIGURE 8.5 Hard contact discharge to temple in a case of suicide. .22 LR. The abrasion rim is irregular but conspicuous. The muzzle imprint is a poorly defined intradermal bruise.

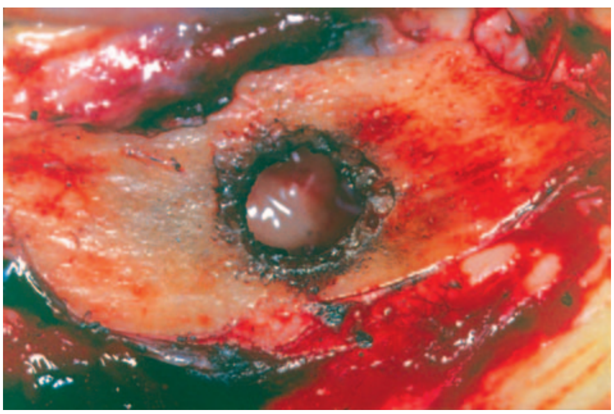


FIGURE 8.3C Scalp reflected. Note very conspicuous unburnt powder particles. The outer bony table shows fine chipping, which is not to be confused with external beveling.

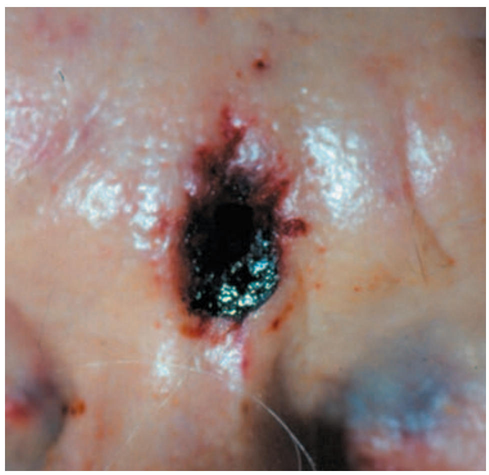


FIGURE 8.6 Contact range discharge to mid forehead in a case of suicide. .22 LR fired from a rifle. The muzzle is angulated upward. Note the gougelike defect with inferior blackening and leading superior-edged splitting lacerations.

FIGURE 8.7 Contact range discharge to the auditory meatus in a case of suicide. .22 LR.. An unusual site of muzzle application is demonstrated. The overlying skin is tightly bound down to the subjacent cartilage, resulting in irregular splitting lacerations.

FIGURE 8.8 Contact range discharge beneath the chin in a case of suicide. .22 LR. The submental area is a common site of election. The abrasion rim is well defined and intensely blackened.

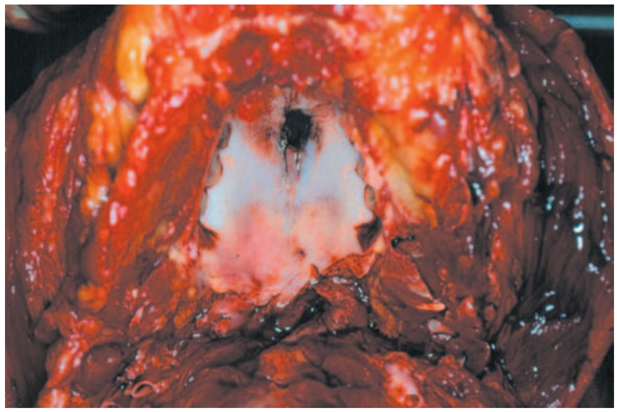


FIGURE 8.9 Contact range discharge to hard palate in a case of suicide. .22 LR. This also represents a common site of election in cases of gunshot suicide. The hole is frequently irregular; anteroposterior splitting lacerations are frequently seen.

FIGURE 8.10A Contact range discharge to left temple in a case of suicide. .22 LR. Imperfect muzzle application resulting in the formation of a zone of eccentric sooting and searing.

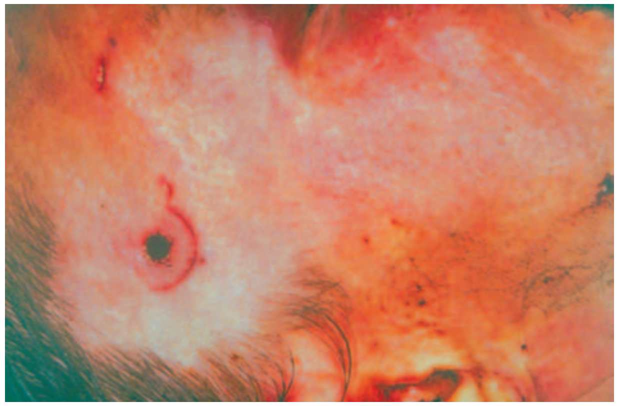


FIGURE 8.11 Hard contact discharge to right temple. .22 LR. Well defined muzzle imprint with sight mount represented. Sawn off .22 rifle.

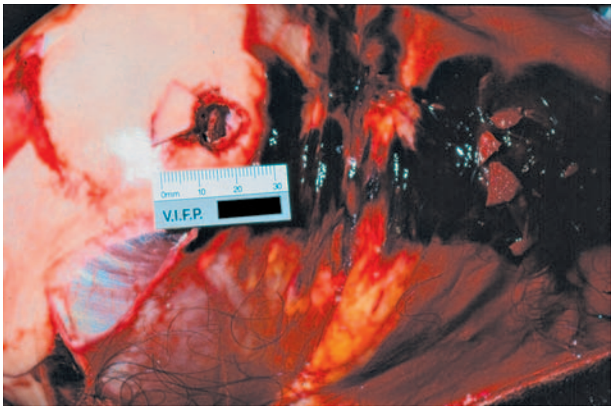


FIGURE 8.10B The bullet did not exit the head but came to rest beneath the scalp on the contralateral side. This is typical of the .22 LR projectile in adult cases.

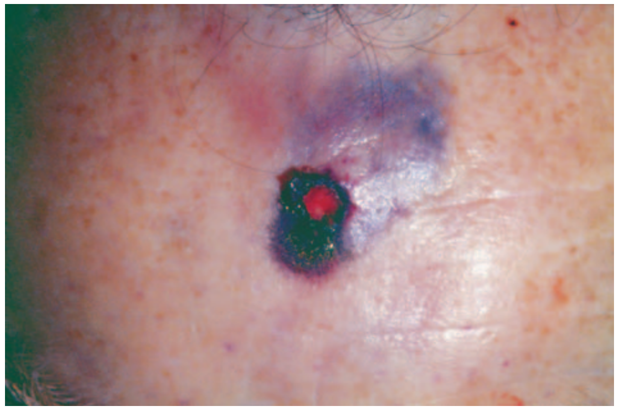


FIGURE 8.12A Contact range discharge with superior angulation of the muzzle to the mid forehead. .22 LR. Note eccentric zone of blackening and a zone of bruising extending towards the vertex.

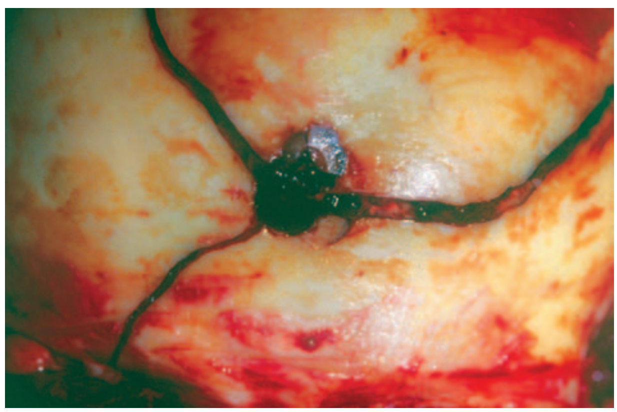


FIGURE 8.12B The classic radiating fracture pattern is demonstrated here. Close examination discloses chipping with bone loss on the superior edge only. The inferior edge represents a neat circular defect. Tangential entry wounds may lead to the formation of the classic "keyhole" phenomenon.

FIGURE 8.13 Tangential contact wound to lower mid chest. Accidental discharge while handling a .22 rifle. Note the elongated ellipse of blackening and the tunnelling passage of the bullet into the subcutis. Bruising is present over the superior edge of the defect.

FIGURE 8.14 Intermediate range discharge .22 LR. Tattooing is less intense in comparison to center fire discharges. The tattooing is more evenly distributed and lacks the formation of concentration around the central defect.

FIGURE 8.15 Distant range discharge to the torso. .22 LR. Note imperfect defect with slightly irregular edges and microsplitting. The appearances here may easily be confused with that of an exit.

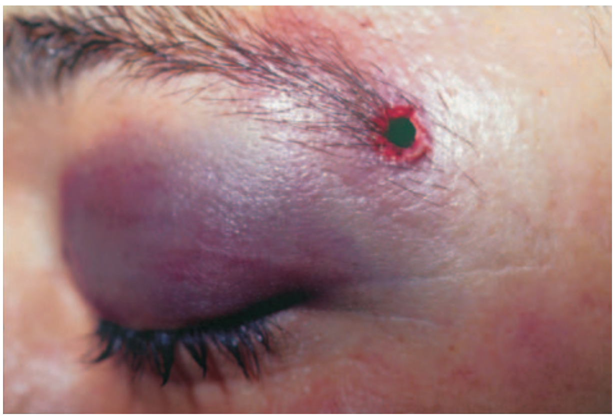


FIGURE 8.16 Distant range discharge to the left temple in a homicide. .22 LR. The abrasion rim is well defined. There is no suggestion of tattooing or regional blackening.

9 Handgun Injury Patterns

Handguns are frequently implicated in homicides, suicides, and the occasional accidental death. It is for this reason that the forensic pathologist should become familiar with the extensive range of injury patterns produced by this class of firearm.

Injury patterns can be classified in the conventional manner of contact, intermediate, and distant range shots. Again, the category of indeterminate can be used if the pattern does not conform.

The calibers commonly encountered in forensic practice include the .32, .38 Special, .357 Magnum, 9 mm, .44 Magnum, and the 45 Automatic Colt Pistol (ACP). Both larger and smaller calibers may occasionally be encountered; these include the 25 ACP and the 50 AE. The .22 rimfire cartridge (which can be fired from a revolver, semiautomatic pistol, or rifle) was dealt with in chapter 8 and it would be impractical to deal with each caliber under the "range" headings because this would lead to enormous overlap.

With few exceptions, all "medium caliber" cartridges produce essentially the same patterns at similar ranges. It goes without saying that heavy caliber rounds are capable of enormous tissue destruction while lighter rounds may produce neat holes with minimal adjacent tissue trauma. For example, the 25 ACP full metal projectile weighs 50 grain, tends to deform in a minimal fashion and readily penetrates the body leaving neat entry and exit defects. The 45 ACP jacketed hollow point projectile can weigh up to 200 grain, readily deforms *in situ*, and may not exit the torso under the same firing conditions as the 25 ACP.

The obvious variables at play here are the increased powder payload (resulting in high velocities) and the differences in both weight and conformation of the projectiles. Having said this, it is timely to emphasize that the pathologist can rarely give an estimate of bullet caliber from inspection of the dimensions of the entry wound alone.

For all intents and purposes, the .38 Special, the .357 Magnum, and 9 mm projectiles are essentially of the same diameter on inspection. The .38 Special cartridge can be chambered and fired from a .357 Magnum revolver. The 9 mm projectile is 355/1000 of an inch in diameter (a caliber of .355).

The intrinsic elasticity of the skin is one factor that cannot be controlled. All pathologists should be familiar with Langer's lines. These lines of natural tension can readily alter the dimension of stab wounds just as readily as bullet wounds.

It would be uncommon for the entry defect to be artefactually increased in size to any significant degree, but the converse is quite common. Most handgun rounds are of low velocity type; that is to say, they travel at or below the speed of sound (1100 f/sec or 340 m/sec). The 25 ACP may travel at speeds of up to 760 f/sec, the 9 mm Winchester Magnum at 1475 f/sec, and the 454 Casull 260 grain (JHP) projectile at 1723 f/sec. It is clear that there is great variance in velocity and this will ultimately translate into varying degrees of tissue destruction, especially in "close range" shots. As most handgun projectiles travel at subsonic speed, it is best to contain the discussion to this group and to expand on the dynamics of high velocity injuries in the chapter dealing with centefire rifle injury patterns.

All projectiles, whether they be round nosed, hollow point, wad cutter, semiwadcutter, fully jacketed, or semijacketed are blunt objects. As such, all bullets push their way through the skin creating a circular laceration, with or without a circumferential abrasion rim.

Passage through solid organs such as the liver will create a fairly well defined bullet track. This mechanism is likened to the pushing of a pencil through similar tissue. The edges of the track may be somewhat friable but there is little in the way of true transient cavity formation.

The degree of bullet deformation frequently determines the degree of tissue destruction. It is on this basis that the concept of "stopping power" has been generated.

Much work has been done to determine the "desired qualities" of bullets to be used by law enforcement agencies to maximize stopping power. It is now generally regarded that a projectile that readily deforms, expends most if not all of its kinetic energy, and causes maximal internal tissue destruction is preferred to a projectile that does not deform, that creates a fine track through the body, exits, and potentially may strike someone else in the process.

We will now examine in some detail the injury patterns seen after the discharge of commonly employed cartridges, using the standard categories of range determination.

CONTACT RANGE

As seen previously, and later under the discussion of smooth bore weapons, contact range can be subdivided into *hard contact, near contact,* and *loose contact* shots.

All calibers are capable of causing various degrees of radial splitting around the entry wound when the skin is overlying bone, the classic region being the temple or forehead. In *hard contact* wounds, the lacerations are often described as having a "star burst" pattern and frequently show separation around the central defect. Depending upon the caliber, the radial splits may be several millimeters in length (as in the 25 ACP) to 60 mm or more with calibers such as the .38 Special. Heavier calibers may cause massive local tissue disruption that cannot readily be distinguished from the disruption caused from high powered hunting rifles or shotguns.

In many cases, careful reconstruction of the wound with critical skin edge apposition will give a fair indication of the muzzle diameter. If the firearm is a semiautomatic pistol, the imprint of the recoil spring guide may also be faithfully represented. The immediate central wound edges will be blackened and seared. Deposition of products of combustion and possibly unburnt propellant may be seen in the depths of the wound. Remember that most pistol round propellants are of fast burning type and thus frequently leave little unburnt powder to be deposited on the skin surface or in the depths of the wound.

Loose contact injuries may occasionally create radial tearing. If present, these will be smaller than ones created on hard contact. Very often, a neat muzzle imprint is produced. The degree of sooting, however, will be increased. The pattern will be circumferential to the central defect if the muzzle is perpendicular and somewhat eccentric if angulated. Local searing and melting of hair shafts may be seen. Close inspection of the hair in cases of loose or intermediate range discharge may reveal a fine dispersion of soot. The hair in the immediate area may have a somewhat "fluffed up" appearance.

Near contact wounds (the muzzle being in close proximity to the skin) will create a good deal of focal sooting with some searing. Radial splitting is much less likely, even with heavy caliber discharges. The diameter of the sooted area may be 40 to 50 mm or so, with even wider concentric "smoke rings" in some cases.

Intraoral discharges can readily cause splitting along the angles of the mouth, paranasal, and maxillary tissues.

Heavy caliber discharges such as the .44 Magnum are quite capable of literally blowing off the victim's head, with a pattern resembling exactly that of intraoral shotgun discharges. The mechanism is essentially the same, relating directly to release of enormous quantities of gas under pressure into a closed space as well as the passage of the projectile.

Contact wounds over loose or poorly supported tissues such as the skin of the abdomen tend not to develop radial splitting lacerations. Large volumes of gas can be accommodated in the loosely bound down fatty tissues and body cavities while the tensile strength of the expanded skin is rarely overcome. The abrasion and grease rims may be seen but can also be readily obscured by heavy deposition of soot.

INTERMEDIATE RANGE

By definition, the injury pattern will comprise the central defect, possibly some sooting and searing, and the classical appearance of multiple small punctate abrasions from unburnt powder that we have come to know as stippling or tattooing.

The propellant used in handgun cartridges is of the fast burning type but may be coarsely granular in appearance. Larger granules offer larger surface areas that will assist in near complete combustion in short time frames. The tattooing after handgun discharges is often striking in its degree of dispersal and often has a distinct punctate appearance. A very rough "rule of thumb" indicates that tattooing is unlikely if the muzzle of the gun is placed beyond two to three barrel lengths from the skin.

DISTANT RANGE

The appearance of the distant range entry wound is nondescript.The only defect is the one caused by the entry of the projectile.There is no thermal effect or tattooing but an abrasion rim may be seen.The defect is usually circular but may be irregular if the bullet has commenced tumbling. The target shooter at 25 meters will attest to bullets entering the target sideways or indeed, backwards. Again it is emphasized that bullet entry diameters can be misleading in determining caliber.

The following photographs will help to outline the often diverse appearance of entry wounds caused by commonly used ammunition calibres and handguns.

FIGURE 9.1 Hard contact entry wound to right temple. Suicide. 9 mm semiautomatic pistol. Note central defect, radial splitting, central blackening, and imprint of the underlugged recoil spring guide.

FIGURE 9.2C The wound edges can often be approximated to reveal the true bore diameter and often, a muzzle imprint. The circular outer table cranial defect is just visible.

FIGURE 9.2A Hard contact entry defect (x 2) to right forehead and temple. .38 Special. Homicide. Note well defined radial splitting and central blackening.

FIGURE 9.2D The muzzle imprint and abrasion rim are now more apparent.

FIGURE 9.2B Close view detailing the radial lacerations and central defect with blackened edges.

FIGURE 9.3 Contact entry wound to right temple. Suicide. .38 Special. Note poorly defined muzzle.imprint and blackened edges.

FIGURE 9.4A Contact wounds to right parietal area. .38 Special. Homicide. Close inspection shows fine soot dispersal in the hair which also appears to be slightly "fluffed up."

FIGURE 9.4B Contact wound to right and near contact to left of photograph. Note marked difference in the diameter of soot dispersal.

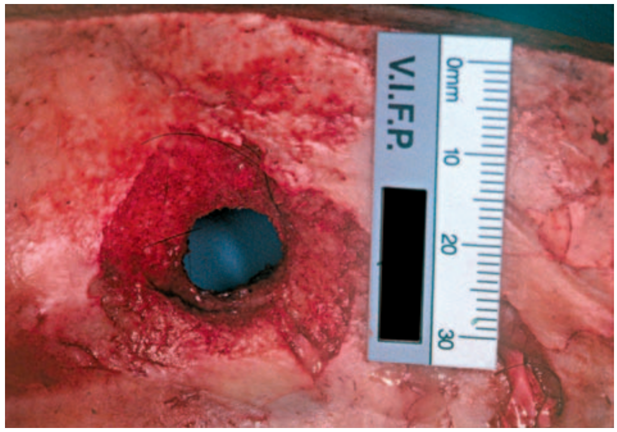


FIGURE 9.5 The internal beveling seen with medium caliber projectiles fired from handguns is generally well defined. .32 Smith and Wesson Long.

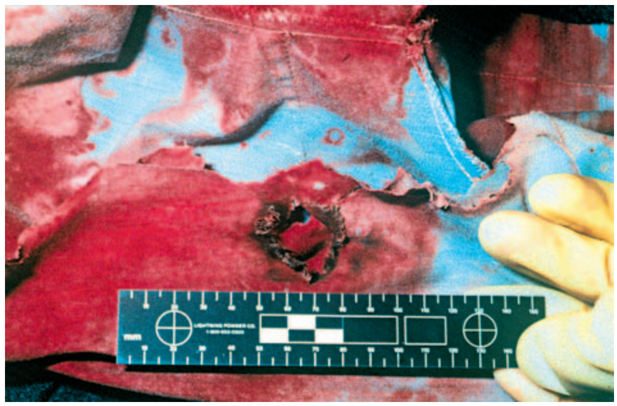


FIGURE 9.6A Hard contact discharge to chest. Suicide. .38 Special. The projectile has been fired through a shirt. Note wide circular defect and blackened abraded edges of the fabric.

FIGURE 9.6B As the skin is less well supported, there is no obvious splitting of the wound edges. Note blackening of the wound edges.

FIGURE 9.7 In this case, a wide zone of sooting is present with poorly defined concentric smoke rings. Some subtle tattooing is noted.

FIGURE 9.8A Intermediate range shot to right temple. Homicide. .38 special. The defect is ovoid. Tattooing is confluent superiorly and more separated inferiorly, indicating the angulation of the shot.

FIGURE 9.8B As above, an inserted probe indicates the angle and passage of the projectile

FIGURE 9.9 A classic dispersal pattern of unburnt powder. Intermediate range. .38 Special. Anterior neck. Homicide.

FIGURE 9.10A The following four photographs demonstrate the shadow effect often seen in tattooing when the victim adopts a defensive posture. Note heavy tattooing to the face. .38 Special. Homicide. Entry below right eye.

FIGURE 9.10B Two further shots to the right parietal area. Note crescentic distribution of tattooing around the more superior wound.

FIGURE 9.10C The hand (with an entry wound through the third digit) is placed over the scalp wound. The odd tattooing pattern is now readily explained as a shadow phenomenon.

FIGURE 9.10D A close view of the overlying third digit. Discreet tattooing is identified on the dorsum of the digit.

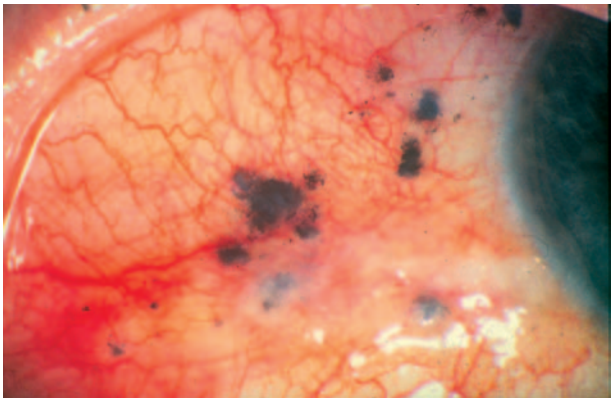


FIGURE 9.11 Tattooing can persist in the living. This photograph shows permanent tattooing involving the conjunctival membrane in a survivor victim. Photograph courtesy of Royal Victorian Eye and Ear Hospital.

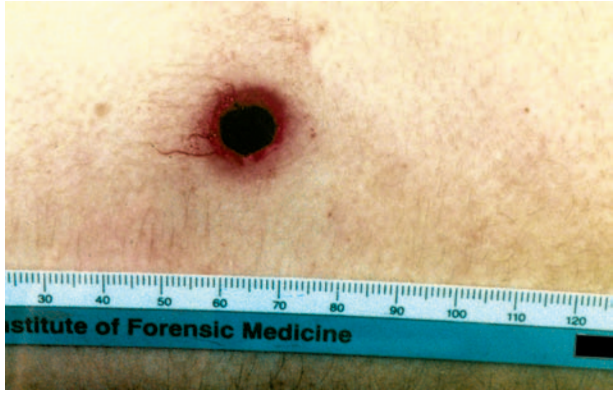


FIGURE 9.12 A typical distant range entry wound. Note well defined and concentric abrasion rim. 9 mm projectile.

A

B

C

FIGURE 9.13A,B,C A series of three photographs showing typical distant range entry wounds in a case of homicide. Note that there is effectively no difference between the entry wound to the face (an unprotected area) and the defects that would have been protected by clothing (arm and buttock). This highlights the protective effect of clothing and justifies use of the term "pathological" range of fire. Note the presence of an intercostal catheter. Removal of this by medical staff or mortuary technicians prior to autopsy may create confusion. The defect may readily mimic a bullet entry or exit wound. Always check the medical notes. On rare occasions, the ER staff may elect to place the intercostal catheter through a preexisting bullet wound.

10 Centerfire Rifle Injury Patterns

The injury patterns after discharge of medium and heavy caliber handguns, and the .22 projectile (which can be fired from both long arm and handgun) have been considered. By and large, these projectiles travel below the speed of sound, and in doing so, create a somewhat different pattern of injury when compared to those of the centerfire rifles. Most projectiles fired from "high caliber" rifles travel at or beyond the speed of sound and are therefore deemed to be "high velocity" by way of classification.

External injury patterns are largely dependent on the distance from the muzzle to the skin. This principle holds for handguns and smooth bore weapons.

By comparison, since most centerfire rifle cartridges are much larger, it follows that the degree of thermal injury, potential for tattooing, and general physical effects of "blast" will be greater.

This is especially true when one considers the effects of the projectile travelling through the internal organs and bone. It is also necessary for the reader to appreciate the concept of temporary and permanent cavity formation — a direct function of the speed of passage of the projectile through the viscera.

A specific chapter on the appearance of exit wounds will be found in chapter 20, but in this chapter, it is pertinent to integrate a discussion on exit wounds as created by this specialized group of projectiles, because the pattern is largely dependent on projectile design.

Centerfire cartridges may be largely grouped into *military* and *sporting* or *hunting* rounds. Military issue cartridges have full metal jacketed projectiles and therefore tend to deform in a minimal fashion and frequently create nondescript defects when they exit the body. The sporting or hunting rounds, by definition, have a soft point and are intended to deform during their passage through tissue. The degree of deformation ranges from virtual disintegration (often leaving a trail of small lead particles—the so called lead "snow storm") to partial peeling back, or complete separation of the jacket and gross deformation of the central core.

As with previous categories of cartridges, the concept of range of "shot" applies here. It is the contact range injury pattern that differs greatly from previously considered projectiles.

CONTACT RANGE

Contact range discharges (next to those of smooth bore weapons — the "shotguns") are responsible for the most horrendous and catastrophic tissue disruption. This relates directly to the much larger quantity of propellant (producing vast quantities of hot gases under extreme pressures), the larger and frequently heavier projectile, and of course, the supersonic speed of the projectile at instant of impact.

The injury pattern may, on occasion, be nothing more than a sharp outline of the muzzle with a central defect representing the projectile. This is uncommon, and is more likely to be seen when the muzzle is placed against pliable and poorly supported tissues such as seen on the abdominal wall or beneath the chin. More frequently however, the hard contact range shot is represented by mass tissue disruption.

There is little difference in *hard* and *near contact* patterns. The massive release of large quantities of gas under extreme pressure will lead to massive splitting of skin and extensive regional thermal effects. The typical radial splitting may be fewer in number but often much larger than is seen with heavy caliber handguns. Radial splits up to 100 mm in length or more are not uncommon.

Secondary splitting along tissue tension lines and fascial planes is commonplace, especially in "head shots." Massive quantities of soot are released, and this black particulate material is frequently driven deep into the immediately subjacent wound and may be forced into and frequently through wound tracks. Indeed, as a significant quantity (up to 15%) of powder is expelled unburnt, it is not uncommon to detect unburnt powder particles at histological level. These particles may readily polarize — a rapid method for detection. Note that some propellant types may completely dissolve during routine tissue processing while being prepared for paraffin sectioning. Cases are on record, however, where sooty material is seen at the point of exit. Regional carbon monoxide absorption may be seen in some cases. Areas of disrupted skeletal muscle may readily absorb this gaseous byproduct and undergo the typical cherry red coloration.

The *near contact* wound may produce similar degrees of disruption, but obviously, with an imperfect seal of muzzle against skin, will create large areas of regional searing and blackening. The abrasion rim may be completely obliterated by soot deposition and thermal effect. The flame emitted from the muzzle may also create thermal effect to overlying clothing. This pattern may be greatly modified by the use of flash suppressors on certain military firearms.

INTERMEDIATE RANGE

There are no surprises here. The degree of tattooing (stippling) is often much greater than the heavy caliber handgun discharge. Again, this is a direct reflection of the quantity of powder contained in the cartridge case. The overlay of soot deposition and tattooing is frequently greater than handgun cartridges of comparable caliber. As a function of barrel length, tattooing may be expected to persist for up to one meter of muzzle distance. The type of propellant used in cartridges is also a definite deciding factor in the formation of tattooing.

The propellant is often of flake design and composed of fast burning nitrocelluse. This tends to combust more completely than does the log or sphere configuration. Since fine flakelike material has little mass, its ability to impact on skin and leave an abrasion is reduced.

DISTANT RANGE

The entry wound of the high velocity projectile may range from a neat round hole to an irregular laceration. The pattern will largely depend on the stability of the projectile in flight. If the projectile impacts on the skin "point first," then the defect can be expected to be essentially circular. Curiously, the abrasion rim is often less well pronounced than is seen with comparable handgun calibers. This is due largely to bullet conformation. Most high velocity projectiles have slender "rocket shaped" tips (i.e., the Spitzer round). Handgun projectiles are decidedly blunt by comparison. The more slender tip of the projectile therefore imparts less local drag on the skin and less local abrasion is seen. If the projectile is unstable early in its flight, or has begun to tumble towards the end, the shape of the entry wound will reflect this phenomenon.

THE WOUND TRACK

It is the consideration of the wound track that separates this group of projectiles from the others. Projectiles travelling at high velocity (greater than the speed of sound) will generate a *temporary cavity* within tissues. This phenomenon is clearly demonstrated in studies using high speed flash photography and blocks of ballistic gelatin. The temporary cavity may reach dimensions of 40–60 times the diameter of the projectile. The greatest internal diameter of the cavity may even pulsate for a short time. Many authorities argue that this transmitted shock wave may create trauma at sites distant from immediate impact. Indeed, it has been postulated that "shock waves" travel through blood filled vessels, later leading to endothelial trauma and thrombosis at distant sites in survivor cases.

There is no doubt that massive destruction is seen in solid organs such as the liver, spleen, heart, and to a lesser degree, the lungs. The liver may be reduced to small pulped fragments. The true track may be hard to demonstrate in the wake of such destruction. Massive expansion of gas and effects caused by a preceding air compression shock wave will obviously create significant trauma to the hollow and gas filled viscera. In survivor cases, a rim of devitalized tissue (the legacy of the temporary cavity) may surround the well defined track caused by the direct passage of the projectile. Occasionally, it may be difficult to differentiate point of entry from exit.

Close examination may show the presence of foreign material such as fabric strands that have entered the body by way of transient negative pressure (suction) caused by the projectile. The use of an illuminated magnifying lamp is invaluable.

EXIT WOUNDS

Although exit wounds will be discussed in chapter 20, it is prudent to include a passage that relates directly to the high velocity projectile. The military round with its full metal jacket may pass through and out of the body with minimal deformation and, when retrieved, show only slight bending or angulation of the tip. As a direct consequence, the exit wound reflects this and may be seen as a relatively neat round to ovoid defect, the diameter of which resembles very closely that of the projectile.

Obviously, the effect of bullets tumbling before entry or during passage through the body will modify the exit wound. In addition, *secondary projectiles* may be set into motion. Tissues such as bone and cartilage may fragment and achieve speeds close to that of the primary projectile. Often, these multiple projectiles radically modify the exit wound complex. High velocity projectiles are, however, renowned for creating devastating large, irregular and untidy exit wounds. It is not so much the speed or type of projectile that determines this, but the location of the maximal point of temporary cavity formation relative to the tissue adjacent to the putative exit point.

In theory, if the maximum point of temporary cavity expansion is closer to the entry, then the exit may be small and neat, providing the projectile does not undergo significant deformation. If, however, the site of maximum temporary cavity formation is within tissues subjacent to the putative point of exit, then a massive blow out may be created. The defect here is often seen as an explosive loss of tissues into the external environment. The skin edges may be ragged, irregular, and elongated. Subjacent adipose tissue and skeletal muscle shards may become externalized. Bone fragments may be expelled completely or may protrude through the irregular exit complex.

The "head shot" often creates the most dramatic effects.The entry wound may be neat or grossly irregular. Often, reconstruction of flayed skin edges will frequently determine the true site of both bullet entry and exit sites. (See photographs at end of chapter). The exit may be essentially an "exploded head" with massive tissue loss through the contralateral surface. Shards of skull with hair-bearing scalp may be retrieved at the scene, often a considerable distance away from the victim. The brain may fragment and be partially expelled through shattered skull, or occasionally be expelled relatively intact—the so called *Kronlein shot*. The author has seen two more or less intact cerebral hemispheres some distance from the victim. The cerebellar hemispheres, when enclosed by the tentorium, tend not to be expelled so readily.

Lastly, it cannot be emphasized too strongly that radiological examination is both mandatory in gunshot cases and also of great assistance in differentiating high velocity from low velocity gunshot. The projectile may fragment almost completely, leaving a telltale trail of fine and coarse lead particles. This is the so called "lead snow storm," so often seen in cases of high powered hunting rifle discharge. If the bullet exits the body, often a hint of fine lead particles remain, sufficient at least to suggest the use of high velocity ammunition.

The following images (some of which are rather graphic) detail the destructive power of high velocity projectiles and also, the vast range of tissue injury patterns commonly seen in forensic practice.

FIGURE 10.1A Catastrophic disruption of the head after a distant range discharge. Homicide. 30-06 Springfield. Note petal like outward disruption of the head in all planes with expulsion of much of the brain.

FIGURE 10.1B After reconstruction, the entry wound is now evident. All elongated curvilinear lacerations lead to a circular defect overlying the left midforehead area.

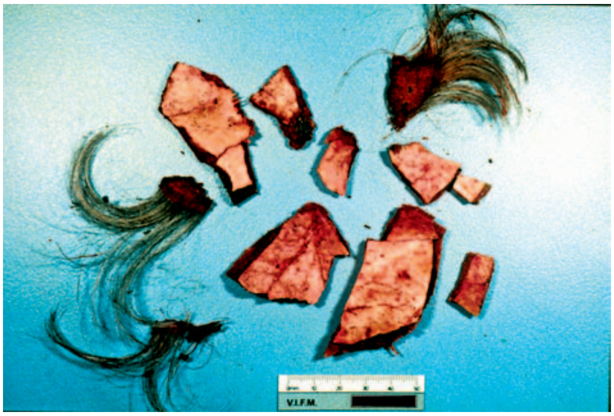


FIGURE 10.2 Multiple irregular fragments of fractured skull and hair-bearing scalp recovered at the scene of a homicide. .308 Winchester. Catastrophic disruption of the cranium is a frequent event. In many cases, reconstruction of the cranium will disclose both entry and exit points.

FIGURE 10.3A Hard contact type high velocity gunshot discharge beneath the chin. Suicide. .308 Winchester. Note soot deposition beneath the chin with radial splitting lacerations. Note also the upward passage of the projectile, which causes linear midline splitting laceration to the facial soft issues. The muzzle was angled slightly anteriorly.

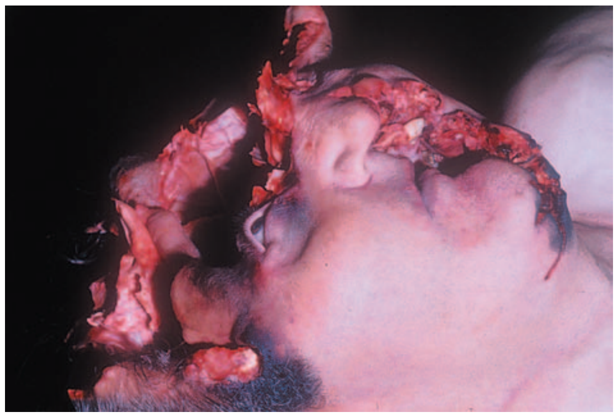


FIGURE 10.3B Victim seen in profile detailing the passage of the projectile. Much of the brain was expelled in this case. Note petal like disruption and collapse of calvarium.

FIGURE 10.4 A typical exit wound through the back of the scalp showing outward petal like disruption of soft tissues and partial exenteration of brain. .303 British. Homicide.

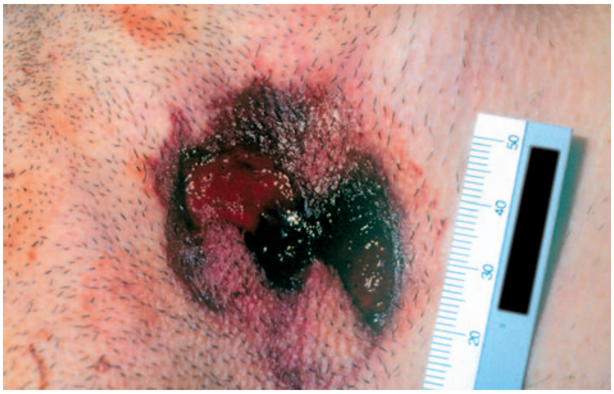


FIGURE 10.5 A well defined circular muzzle imprint in a case of hard contact discharge. Muzzle placed beneath right side of chin. .30-06 hunting rifle. Suicide.

FIGURE 10.6A Hard contact discharge to left chest. 45-70. Government. Suicide. The muzzle has been placed over light clothing. The force of the explosion has punched a near perfectly circular 30 mm hole through the skin. Considerable sooty material is present within the depths of the wound.

FIGURE 10.6B Note entry wound above left nipple. Note also prominent linear intradermal bruises over axillary area and patchy areas of bruising and abrasion on medial aspect of upper arm. These lines represent forceful expansion of skin against items of clothing at the instant of discharge.

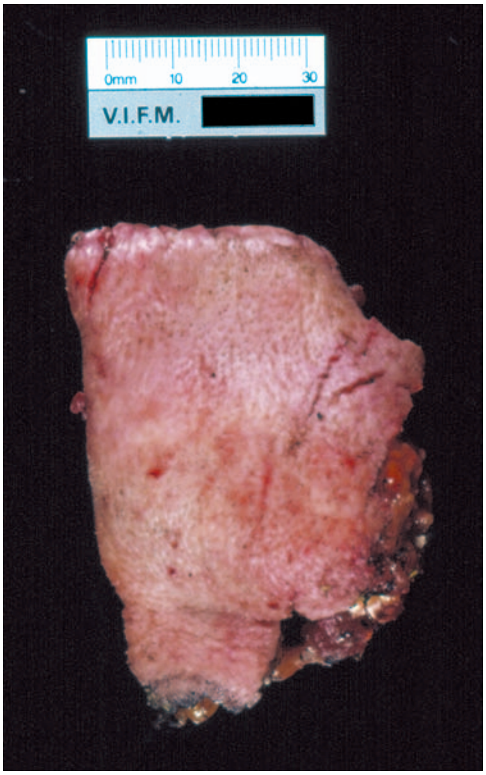


FIGURE 10.7 An unusual tissue fragment recovered at a suicide scene. The specimen consists of part of the lower lip and chin. Note semicircular muzzle imprint and soot deposition at lower edge of tissue fragment. .303 British.

FIGURE 10.8 A tangential gunshot wound with entry anterior to the right ear and exit through the right occipital area. Note regional soot deposition and extensive external disruption of scalp and brain substance.

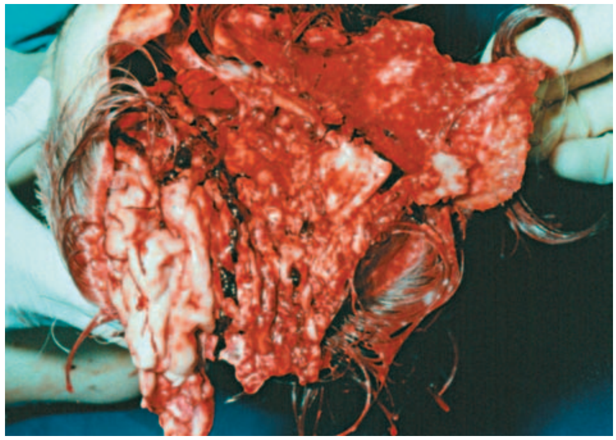


FIGURE 10.9 Massive disruption of the calvarium with subtotal exenteration of brain substance. Tangential wound from forehead to occiput. Homicide. On rare occasions, the brain may be expelled more or less intact (Kronlein shot).

FIGURE 10.10 A complex injury through the left cheek. Note ovoid defect with radial splitting lacerations and cleaving of skin and soft tissues along Langer's lines. Distant range shot.

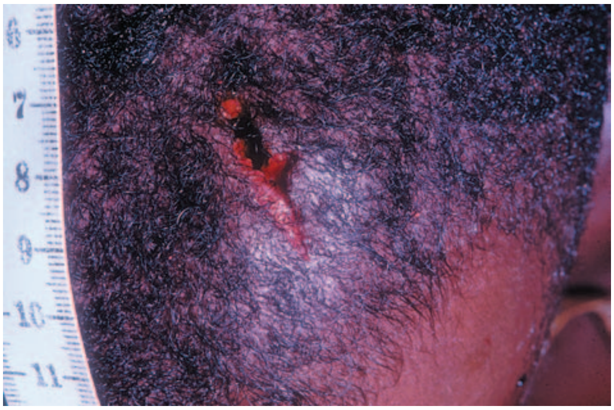


FIGURE 10.11 An irregular oblique oriented laceration with some right angular splitting. This defect is typical of exit wounds at distant range. The injury is nondescript. Wound interpretation may be problematic in dark skinned people. Histological examination of skin edges is advised.

FIGURE 10.12 The typical appearance of an exit wound (bottom right) with several smaller exit wounds caused by the passage of secondary projectiles such as bone and/or bullet jacketing.

FIGURE 10.13 Extensive skeletal trauma after high velocity gunshot injury. Typically, many bone fragments are seen and many others expelled from the wound area. In this case, dissection has been performed to display the extent of bony injury.

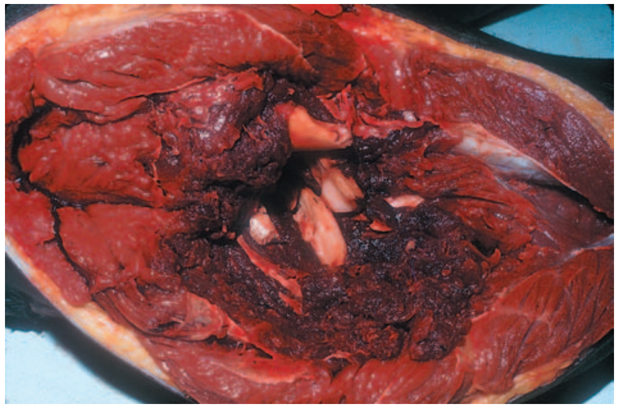


FIGURE 10.14 A further example of extensive skeletal disruption and muscle hemorrhage after the passage of a high velocity projectile through a limb.

FIGURE 10.15 An unusual wound presentation. The bullet has entered the skin leaving a defect that matches almost exactly that of the profile of the projectile itself. Part of the skin edge has been excised to demonstrate the projectile in situ. This presentation may be seen as the bullet loses aerodynamic stability and tumbles through space prior to striking the target.

11 Shotgun Injury Patterns

The pattern of injury after shotgun discharge is diverse. The interpretation of injury patterns is greatly assisted by a knowledge of the components of the standard shotgun cartridge. These have been described in detail in a previous chapter so only the expelled components will be mentioned here.

At the instant of discharge, the pellet aggregate exits the muzzle of the gun as a fast moving, effectively solid mass. The velocity of the shot aggregate is approximately 365 m/s. In addition to the pellets, the plastic piston or shot cards and the wad are also expelled. However, because these components are aerodynamically unstable, they fall away rapidly as the shot aggregate moves forward. The outline of shot cards, wadding, and the piston may be imprinted on the skin of the victim.

Test firing can enable the forensic pathologist to reliably estimate the shot range as long as the same gun and ammunition type are used.

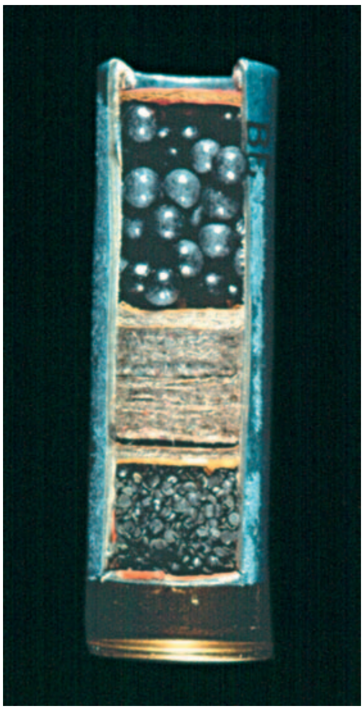
The piston helps to keep the shot in an aggregate until it falls away and also reduces metallic scouring on the inside of the barrel. The standard 12 G piston has four petals. Each petal opens within a meter or so of the muzzle; this greatly increases the degree of air friction and ultimately, the piston will fall to the ground.

Well defined rectangular abrasions may be seen radiating from the entry wound. This injury pattern is often called "petal slap" or "wad slap." The .410 caliber shot shell piston typically has three petals. As the piston falls, it often impacts the victim at a lower level than the central shot aggregate. The identification of the piston petal slap and retrieval of the piston are of great importance, both to the forensic pathologist and the ballistics expert.

The following photographic images demonstrate the function of the piston and its appearance at varying stages of petal deployment.

Inspection of the high speed photographic images at the instant of discharge demonstrate very adequately how quickly the petals begin to open after emergence from the barrel.

It can be seen that the pellets are kept in a tight aggregate. An instant after emergence from the muzzle, it can be seen that the pellets are well in advance of the piston. The last high speed image shows definite deployment of all four petal leaflets. The second series of photographs demonstrates the appearance of an unspent plastic piston and the appearances of the petals in varying stages of deployment. Note also the very definite indentation of the contained pellets.

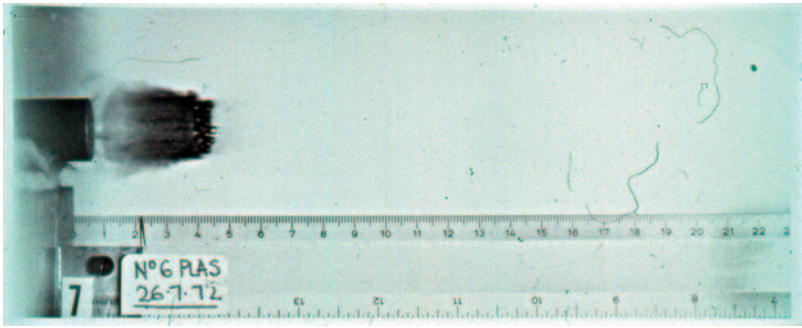


A

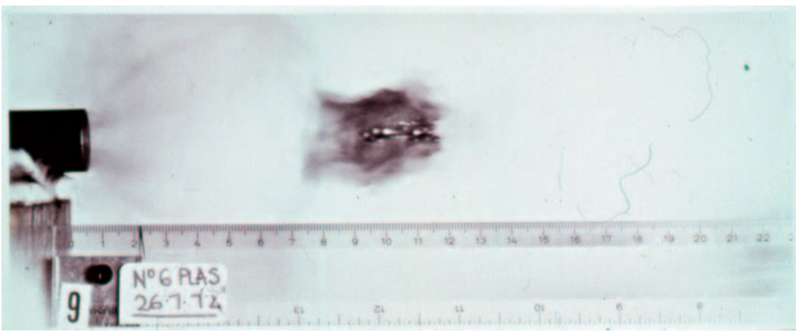
B

FIGURE 11.1A, B A knowledge of the components of shotgun cartridges will greatly assist in the interpretation of injuries.

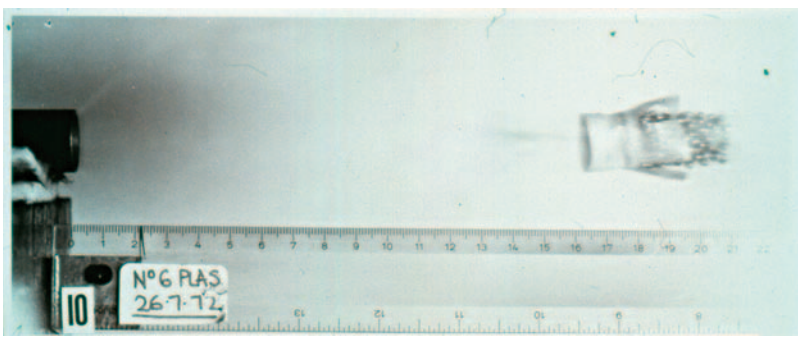
A



B



C



D

FIGURE 11.2A, B, C, D High speed photography demonstrating pellet aggregate and piston at the instant of discharge. Note early deployment of *piston petals*.

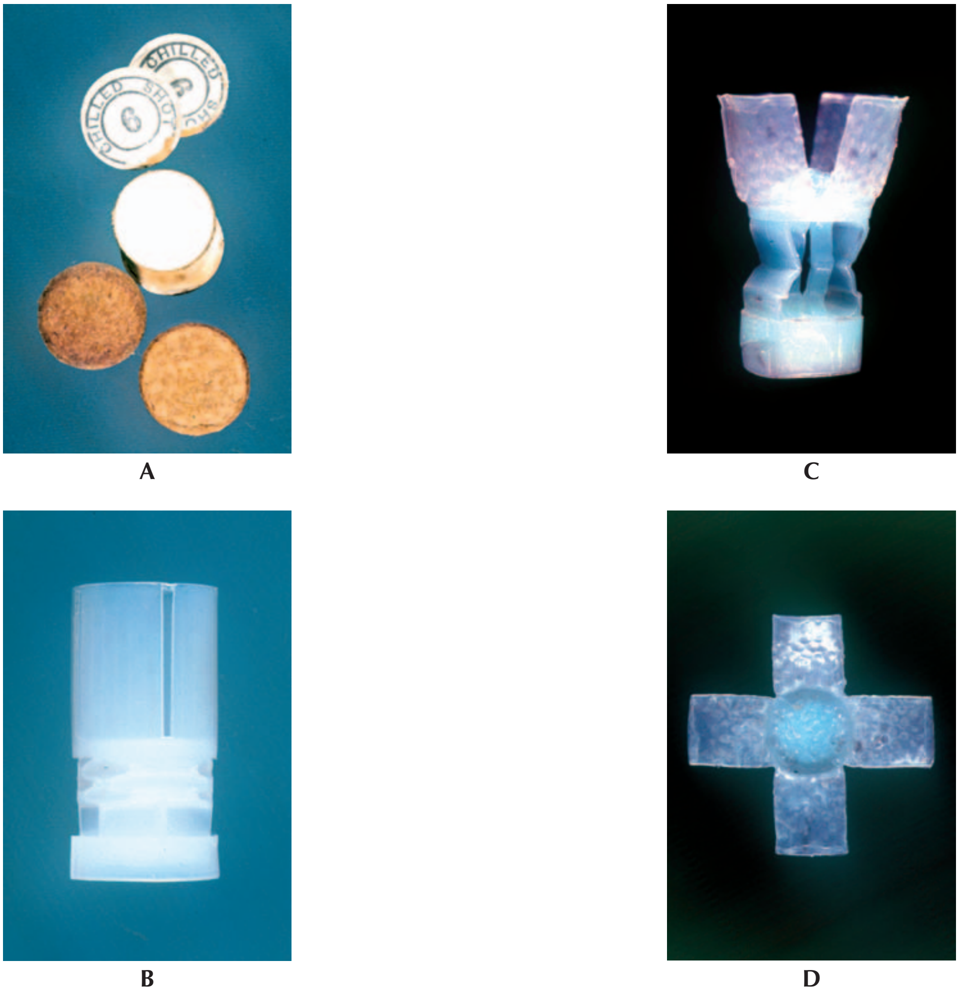


FIGURE 11.3A, B, C, D Unspent cards and wadding at upper left. Unspent (B) and spent plastic pistons showing varying stages of petal deployment. Note discreet indentation of contained pellets.

The pellet aggregate tends to separate at a range of 1 to 2 m from the muzzle to form a slightly irregular hole with peripheral scalloping — commonly termed a "rat hole." From this point onward, more and more pellets separate, forming an irregular central defect with satellite perforations. Ultimately, the pellets separate until all impact on the target as individual small holes, the size of which equate with the dimension of the shot.

The dispersal from the muzzle is that of a shallow cone. The degree of dispersal can be deliberately modified by the use of a barrel *choke*. A choke is a slight conical taper located in the last few inches of the barrel. It may be a permanent fixture of the gun or alternatively, interchangeable chokes may be attached. There are several degrees of choke, which are commonly listed as *improved cylinder*, *modified choke*, *half choke*, and *full choke*. The true cylindrical barrel does not contain a choke.

The actual reduction of internal barrel diameter may be in the order of several thousandths of an inch but this will translate into a reduction of pellet dispersal over distance. The following photographs depict dispersal of shot over distances of 3, 5, 7, and 9 m from the muzzle. The 3 m shot discloses an irregular central defect representing the main pellet mass and passage of the piston. Even at this distance, it is evident that many pellets have left the main central aggregate.

The remaining photographs depict a further extended dispersal of pellets until almost all are flying individually.

The degree of pellet spread can be estimated and used as a rough guide (a rule of thumb) to ascertain distance from muzzle to victim. The only immediate apparent use for this rule of thumb is to decide whether the case in question constitutes a homicide or suicide. For rough assessment at the scene, place a ruler through the central aggregate or at least the central point of the dispersal pattern and then measure the diameter. For each 3 cm of dispersal we can estimate 1 meter of distance between muzzle and victim. It can only be used if there is no intermediate target and certainly cannot be used in the

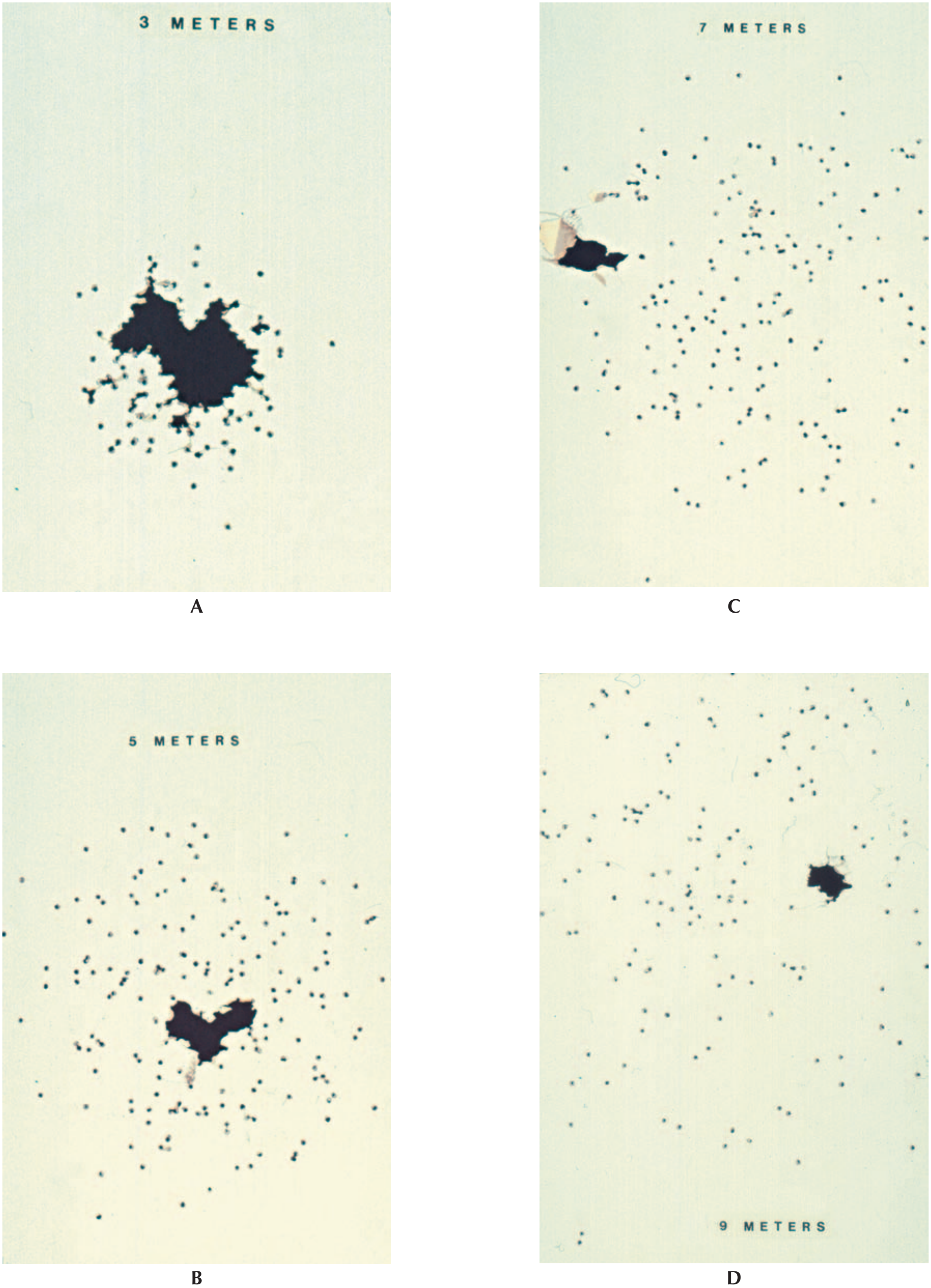


FIGURE 11.4A, B, C, D A series of test fire cards depicting the gradual dispersal of shot from the central aggregate.

case of examination of the illuminated X-ray image. Remember that this estmate is intended as a rough guide only and should not be relied upon in a court of law. Test firing is mandatory to ascertain an accurate muzzle to target distance.

As soon as the pellet aggregate strikes a surface, all pellets suddenly disperse in random fashion. This phenomenon is likened to the spread of balls on a pool table at the instant of the break.

The propellant of the standard shotgun cartridge is typically of slow burning type. This powder formulation allows sufficient time for pressures to build up within the barrel to effectively expel the shot. As a consequence, most if not all of the propellant is consumed on discharge. Given also the comparative wider bore of shotguns, this leaves little unburnt powder to cause the typical tattooing or stippling as is classically seen in rifled weapons.

The cone of dispersal of soot is wider, less concentrated and less likely to be seen to deposit on the skin over similar distances.

Shotgun discharges are certainly lethal at close range, but this rapidly declines over distance. At extreme range, and certainly when all pellets are individually dispersed, the likelihood of death is greatly diminished. It is acknowledged that individual pellets may lead to death if the victim is struck in particularly vulnerable areas such as the eye, neck and temple. This is certainly not the case however when solid projectiles such as the Foster, Sabot, and Brenneke rounds are discharged. These specialized projectiles are essentially as lethal as their rifled counterparts. In a standard forensic practice, these rounds however are less likely to be encountered.

The nomenclature of shot range estimation for the shotgun is essentially that used for the rifled weapon and shotgun injury can be accommodated under the broad headings of contact, intermediate and distant range shot. Some authors, as previously indicated, prefer to group into more indefinite categories such as close range, short to mid range and mid to distant range. This concept is perfectly acceptable and even more so, understandable, given the added complexities of the effect of wad or petal slap superimposed on thermal effect, tattooing, and the effect of impact from inert filler.

This leads to the question: does the effect of petal slap convert a wound into the intermediate category even if no powder residue is seen on the body?

The injury patterns are variable; again largely driven by the extreme diversity of the ammunition. The range of pellet dimension is wide, some cartridges contain inert filler that may abrade the skin, the petal injury pattern is dependent on its aerodynamic quality, and the propellant may be of fast or slow burning type, particularly if the projectile is a solid slug.

The effects of the choke also need to be considered. In all, this creates a wide diversity of wound patterns that may confound the examining pathologist. It cannot be too strongly emphasized that test firing is mandatory. The same gun (with same degree of choke) and same ammunition must be used to rationalize the results.

We will now consider the salient qualities of shot range, using the conventional categories of contact, intermediate and distant.

CONTACT RANGE

The effects of a contact range shotgun discharge are devastating and frequently lethal. If the muzzle is placed hard against the skin (*hard contact*), then virtually all of the expelled gas, burnt and unburnt powder, all pellets, and wadding enter the body. The pellet aggregate at this point may be considered as a solid mass moving at extreme speed and this will have the same effect as the solid slugs such as the Brenneke and Foster projectiles. The exit wound pattern may differ, however.

In the case of double barreled weapons, the sudden and catastrophic expansion of soft tissues will frequently create a faithful reproduction of the muzzle of the gun in the form of a circular laceration and abrasion. Examination of the wound quickly indicates the configuration of the barrels. One can quickly determine whether the barrels are of side by side or over and under design. In addition, the impact of the front sight is often apparent. The imprint of the nonfiring barrel will be seen immediately adjacent to the blackened hole representing the discharging barrel.

The diameter of the defect equates very closely with the internal diameter of the muzzle. In the case of the 12 gauge shotgun, this will be approximately 20 mm. The wound edge is generally circular in configuration, with considerable blackening of the edges. If the seal against the skin is slightly imperfect, either from less than perpendicular placement of the muzzle or due to easing of pressure at the instant of discharge, radial or ovoid side venting of soot will be seen. Since the forces generated are tremendous, radial splitting lacerations are often present. This is particularly so if the barrel is placed under the chin or against areas where the skin is bound down to bone. Intraoral discharges often result in massive splitting of the skin along the edges of the mouth, maxillary areas, paranasal soft tissue, and cheeks. This is a direct function of the facial soft tissues ballooning out as the gases enter the buccal cavity.

Vast quantities of carbon monoxide are generated during propellant combustion. Regional carbon monoxide absorption may occur, imparting a distinct cherry red coloration to disrupted muscle. Soot deposition is seen within the depths of the wound.

In the case of intraoral discharge, the exit may be seen as complete destruction of the cranium outwardly in a petal like fashion. Often the brain is expelled, either in a fragmented fashion, or less frequently as intact cerebral hemispheres. This latter and unusual phenomenon is called a *Kronlein shot*. The Kronlein shot may also be seen after head shots with high powered centerfire rifles.

A *loose contact shot* (the muzzle placed against the skin but insufficient to indent it) may be seen as a neat, blackened, and seared 20 mm diameter circular defect. An imprint of the nonfiring barrel and front sight may still be seen. However, the likelihood of massive splitting of soft tissues is reduced.

The *near contact* wound is seen as a circular defect with extensive searing and blackening. Close inspection may demonstrate the presence of focal thermal injury to adjacent hair shafts. Often the ends of the hair shafts are melted forming small club shaped structures. There will be no rebound effect and therefore no muzzle or front sight imprint. Since the muzzle is close to but not against the skin (say a separation of 1 to 2 cm), there will be considerable radial dispersion of soot surrounding the central defect.

INTERMEDIATE RANGE

By definition, the intermediate range shot will display the typical stippling or tattooing from unburnt propellant. The dispersal, however, is less intense than with rifled weapons, as much of the propellant has been consumed within the barrel. Tattooing may be expected up to 1 m from the muzzle. The thermal effects may still be seen in many cases. Often, inert filler is used in rounds containing larger pellets (SG or buckshot). These inert particles may also contribute to the tattooing. Since the particles are frequently larger than that of the propellant, they tend to travel somewhat further. There may be an intermingling of tattooing with the emergence of petal slap.

DISTANT RANGE

At this point, the effects of barrel choke will begin to manifest. The slap abrasion of wadding or piston will also be seen. From a distance of 1-2 m, the pellets begin to separate from the central aggregate, beginning first as a “rat hole” and later as an irregular central hole with satellite fliers. Ultimately, all pellets fly individually given sufficient distance.

General comments can be made for the standard 12 gauge round fired from a cylindrical (nonchoked) barrel:

At *1-2 m*, the petals of the piston have opened and will impact on the skin, leaving its telltale pattern so readily recognized by the forensic pathologist. Given this, it is surprising how many pathologists fail to recognize this phenomenon. This relates, I am sure, to a lack of understanding of the components of the standard shotgun cartridge. The radial abrasion may be subtle if the petals have not fully opened. The wadding/piston generally penetrates the body and is readily extracted at autopsy.

By *2.0 m*, the central aggregate of shot has entered the body but there is now a conspicuous separation of individual shot pellets in close and concentric proximity. This pattern is frequently seen in homicidal shootings and occasionally in accidental ones, but never, in suicide unless some form of supporting apparatus and remote firing mechanism are employed. The wad or piston will still strike the skin but often at a point lower than the main pellet aggregate entry.

By *3.0 m*, the spread is demonstrably wider again. The central aggregate is less well defined and individual fliers are seen in rough concentric dispersion.The wad/piston may still reach the body but may either rebound or impact onto the skin below the line of fire. In the case of larger pellets (such as the SG round having nine balls), all by now have completely separated and impact in close proximity to each other.

From *4 to 5 m*, most if not all pellets have separated. Some may still travel together to some degree. The reader should again refer to the photographs showing pellet dispersal after test card firing. By definition, tattooing and thermal effects will not be seen.

EXIT WOUNDS

In the case of contact wounds to the head from shotgun rounds containing standard pellets (say No. 5 or 6), the exit wound is often catastrophic. The head may literally explode in a petal like fashion. Skin, skull, and brain may scatter over a great distance. Skull fragments are often held together in a tenuous fashion by fascia and skin. Remember, though, that this is also a function of rapid gas expansion as well as pellet impact. Standard pellet sizes (No. 5 or 6) fired from a range of 1 to 2 m rarely, if ever, exit in a true sense, unless the site of impact is narrow. Shots to the torso disperse the pellets into deeper tissues and viscera.

Larger shot sizes such as the SG frequently do exit. Often the pathologist will see a typical contact, intermediate or distant range entry, with up to nine discreet exit holes on the opposing aspect of the body. Large slug type projectiles almost always exit at close range.

INTERMEDIARY TARGETS

The intermediate target may constitute glass (such as windscreen or window), wood (such as a door), plaster board or human tissue. At the instant of impact, all pellets in the central aggregate will disperse in random fashion. The interaction of the intermediary target means that many of the pellets will not impact onto the intended target. A shot at close range through glass may well create an injury pattern resembling that of a distant range shot. The injury pattern may be further complicated by the impact of secondary projectiles such as small glass fragments.

GLANCING OR TANGENTIAL INJURY

If the pellets strike the target in a tangential fashion, typical grazing wounds will be seen. Often the pellets or balls become embedded in tissue and may be readily palpated at autopsy. The pellets may be just under the skin, creating a point of blanching and adjacent bruising. The pattern of shot dispersal on the body will frequently inform the pathologist as to the position of the victim at the instant of discharge.

INVESTIGATIONS

Radiology is both mandatory and highly informative. The pattern of dispersal of shot on X-ray is *not* indicative of the range of the shot (as per the rule of thumb) but will indicate the shot size. Remember also that radiological examination will artefactually enhance the pellet size on the X-ray plate by virtue of conical dispersion of X-rays at the moment of exposure.

A sample of the shot should be retained as should all wadding and piston fragments. These are invaluable as evidential material and aid the ballistics expert in identification of the ammunition type.

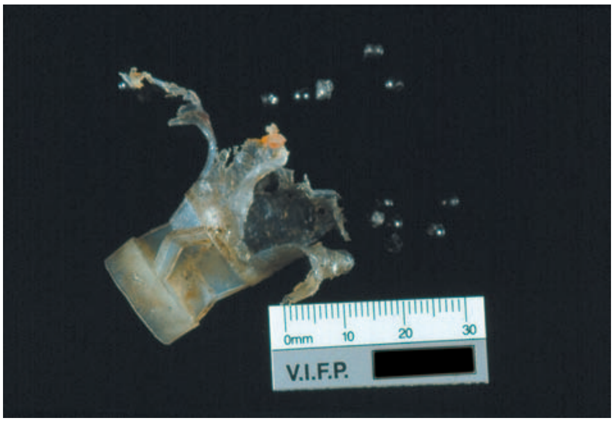


FIGURE 11.5 Always seek and retain a representative sample of shot and the wadding/piston as evidence.

FIGURE 11.6A Extensive splitting of the facial skin and soft tissues from an intraoral placement and discharge of a 12 gauge shotgun.

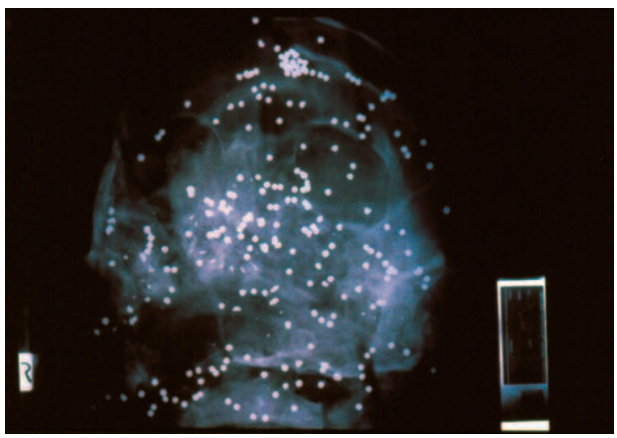


FIGURE 11.6B In this case, the pellets did not exit and the scalp remained intact. The X-ray shows extensive cranial fracture. Many pellets are seen to line the inner table.

FIGURE 11.7 A more extreme example of facial splitting from an intraoral discharge. Conspicuous splitting is noted along the paranasal and maxillary areas with extension to the outer angles of the mouth.

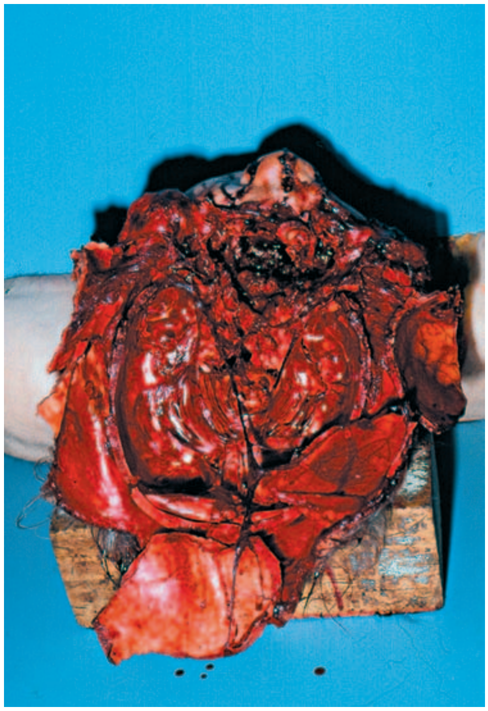


FIGURE 11.8B Close examination shows the cerebellar hemispheres in situ, as is frequently the case.

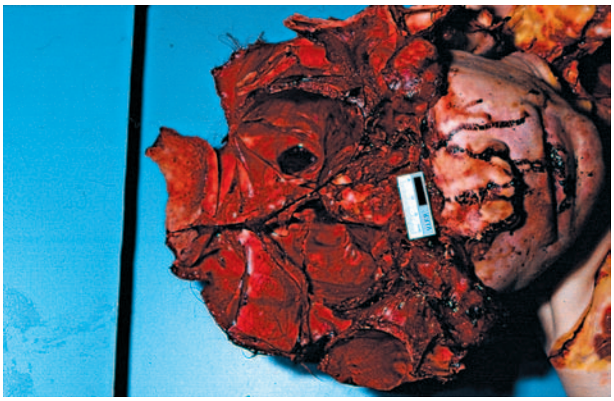


FIGURE 11.8A The catastrophic effect of an intraoral discharge. The head has completely opened up in a petal like fashion.

FIGURE 11.9 Facial disruption as seen when the muzzle is placed beneath the chin. In this case, the gun was angled somewhat anteriorly, sparing much of the brain. Death would be expected although survival is seen in some exceptional cases.

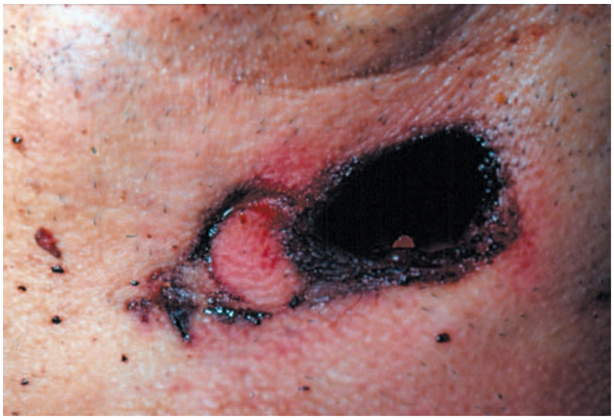


FIGURE 11.10A Contact range discharge to the neck. 12 G shotgun. Note ovoid defect with seared edges and the faithful imprint abrasion of the nonfiring muzzle. Note also the imprint of the front sight.

FIGURE 11.10B A close view of the weapon in question — an over and under double barreled 12 G shotgun.

FIGURE 11.11 Loose contact range discharge to the left temple — suicide. Note ovoid defect with eccentric soot dispersal.

FIGURE 11.12A An unusual site of election in a case of suicide. 12 G shotgun. The entry point is the anterior neck. Note linear superoinferior splitting and larger exit through right lateral neck.

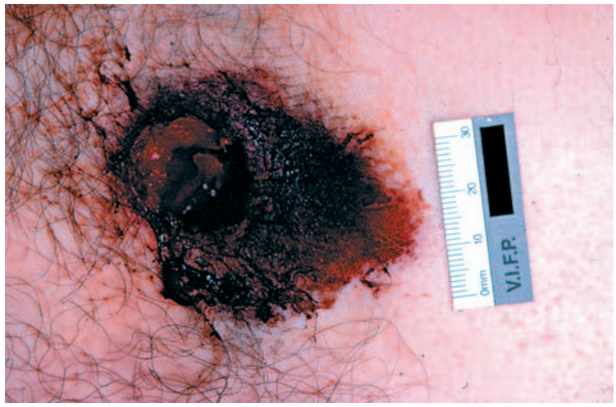


FIGURE 11.13 Loose contact shot to mid chest. Suicide. Note neat 20 mm diameter defect with eccentric soot deposition.

FIGURE 11.14A Loose contact discharge to left chest - suicide. SG round. A disrupted and fractured rib protrudes through the defect.

FIGURE 11.12B Closer view showing transverse placement of the muzzle of a double barrel shotgun and conspicuous longitudinal splitting in the midline.

FIGURE 14B Exit wound from SG round. Eight of the nine pellets have completely penetrated the body. The ninth pellet can just be seen beneath the skin as a pale bulge with surrounding bruising.

FIGURE 11.15 Loose contact discharge to abdomen. It is not uncommon for soft tissues such as omentum, mesentery, or bowel to protrude through such a defect. A circular rim of tissue can be seen at the most inferior edge of the protruding tissues.

FIGURE 11.16 Intermediate range discharge to left preauricular area. Note central defect (still approximately 20 mm in diameter) with concentric sooting and tattooing showing a slight eccentric dispersal.

IGURE 11.17 Intermediate range shot to mid forehead. .410 calibre round. Note smaller central defect, subtle tattooing, and peripheral searing.

FIGURE 11.18A "Rat hole" defect to lower right neck/upper chest area. Homicide. 12 G discharge. Note subtle scalloping of edges. Range 1 to 2 m.

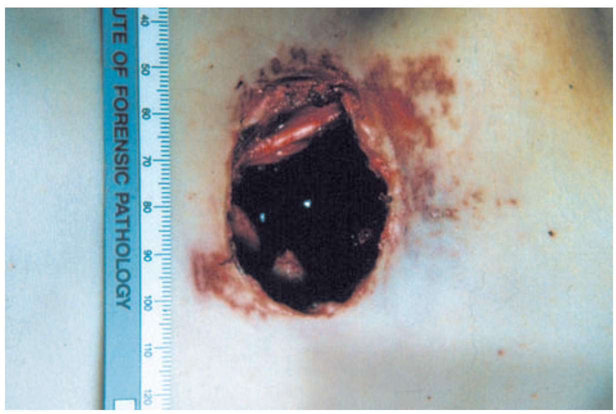


FIGURE 11.18B Close view of "rat hole." The scalloping is now more obvious. The irregularity of the superior edge is largely due to impact against the subjacent clavicle, which is now comminuted.

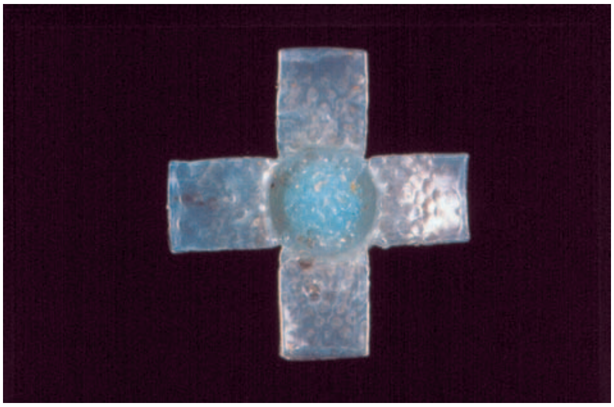


FIGURE 11.19 A fully opened piston. Note the radial separation and pellet indentation. Always retrieve and submit the piston/wad as evidence.

FIGURE 11.20 Classic 12 G petal slap. The wound edges are distinctly scalloped. Range 1 to 2 m. The piston can be seen in the depths of the wound.

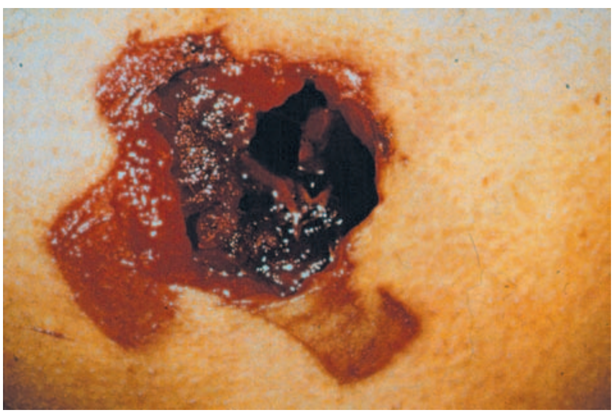


FIGURE 11.21 A further fine example of petal slap. The petal in this case has impacted in a slightly eccentric fashion.

FIGURE 11.22 Petal slap. .410 calibre discharge. Intermediate range. A small amount of tattooing is identified.

FIGURE 11.23 "Rat hole" with a few early fliers. Range 1 to 2 m. 12 G shotgun. Homicide.

FIGURE 11.24A Distant range shot to mid abdomen. SG round — homicide. Range approximately 3 m. Note roughly concentric pattern of projectiles and imprint of wadding.

FIGURE 11.24B The deceased suffered a further shot to the back. In this view, several exit points of the SG pellets are seen, as well as a rat hole with individual wadding abrasions. Range 1 to 2 m.

FIGURE 11.25 A further example of an SG wound. Homicide. Impact to upper mid chest. Note again the centrally located wadding impact abrasion.

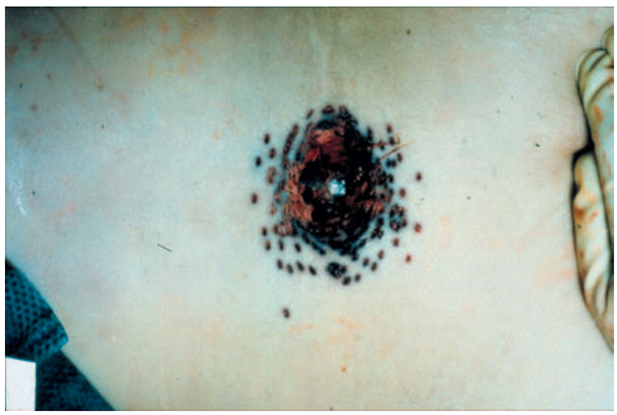


FIGURE 11.26 An excellent example of established pellet separation from the central aggregate. Range 2 to 3 m. The piston is visible in the depths of the wound.

FIGURE 11.27 An example of a glancing or tangential wound. The pellets have impacted at a tangent and have gouged into the tissues. An embedded pellet is marked by a ring and arrow.

FIGURE 11.28 Near complete separation of pellets. The area of impact is the left axilla. The location of the impact is highly suggestive of a defensive posture. Range approximately 4 m.

FIGURE 11.29 A typical spread of shot at distant range. Most pellets have separated. The "rule of thumb" could be applied in this case.

FIGURE 11.30A The human body as an intermediary target. This demonstrates a through and through injury, entering first the left arm with pellets widely separating and impacting onto the left flank. Note plastic piston in elbow.

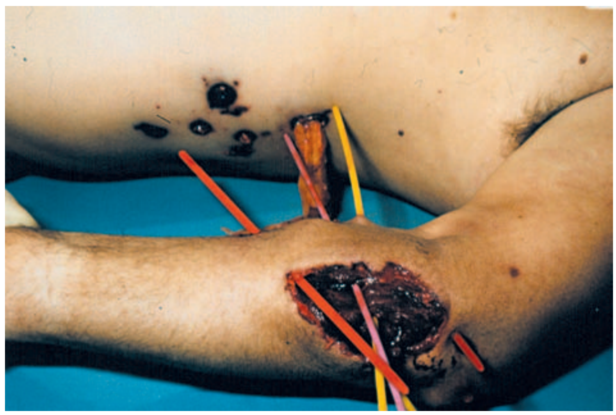


FIGURE 11.30B This has caused premature dispersal of pellets in a direction indicated by the inserted probes. Note extruded fatty tissues from one of the entry wounds.

12 Black Powder Firearms

Black powder firearms are rarely used in homicides. The vast majority of these weapons are owned by enthusiasts belonging to dedicated black powder clubs or pistol clubs catering to the black powder shooter. Although genuine pieces may be used for practice or in competition, most are now in the province of private collections and rarely used for active firing. Many excellent reproduction firearms are currently on the market; most are made in a style little changed from their inception. Colt, Pedersoli, Thompson, Uberti and Sturme-Ruger offer a wide range of finely engineered pieces for the amateur shooter. Many of the black powder pieces available comprise the "cap and ball" design.

Although the intention of this book is to describe and display the many and varied patterns of gunshot injury, it is prudent at this point to outline the fundamental differences between flint lock and cap and ball firearms.

FLINT LOCK RIFLES AND PISTOLS

The flint lock firearm relies on the spark generated by striking a fragment of flint against an abrasive surface to initiate the explosion of gun powder within the barrel. The earliest firearms relied on a lit taper to initiate the detonation by the use of a trigger and lever driven device or by direct manual application. The flint lock weapon has a shallow pan containing finely divided gun powder to receive the spark from the abraded flint. This pan (called the frizzen pan) accommodates the flash of gun powder that secondarily ignites the powder in the barrel, thus expelling the projectile. The loading of the gun differs little from that employed in cap and ball weapons.

THE CAP AND BALL REVOLVER

The cap and ball revolver relies on the ignition being generated by the spark from a percussion cap. The percussion cap is applied to a nipple immediately behind the chamber of the cylinder, which is subsequently struck by the hammer. The chamber of the cylinder may be filled with gun powder either by disengaging the cylinder from the body of the gun or by loading in situ.

A measured amount of black powder, the traditional gun powder composed of sulfur, charcoal, and saltpeter, is poured into the chamber of the cylinder from a flask or powder horn. The length of the dispensing nozzle predetermines the amount of powder delivered. Although the projectile is usually a round ball of cast lead, some shooters prefer a conical bullet.

In many cases, the projectile is cast at home by the shooter who uses a small electrically heated kettle and a precision engineered bullet mold of certain caliber and conformation. Commercially prepared projectiles of varying hardness, caliber, and contour are also available. The diameter of the projectile is slightly larger than the caliber of the chamber, usually in the order of some 0.001 to 0.002 inches. The caliber of black powder pistol balls is commonly 0.45 inch although projectiles may range from 0.31 to 0.50 or larger.

The projectile is rammed home, either by disengaging the cylinder and using a press of predetermined depth, or by using the built-in lever underlugged to the barrel. In the case of flint lock pistols and rifles, the ball is seated using a straight ramrod after filling the barrel with a predetermined volume of black powder.

Because the black powder cap and ball pistol is more likely to be encountered in forensic work, the following details are pertinent.

The shooter may either elect to place a disc of woven material between the powder and ball or to overlay the ball with grease to prevent a potential flashover phenomenon. This rare event involves the transfer of sparks into the nonfiring chamber, potentially causing a catastrophic chain reaction. The disc is expelled at the time of the discharge. Being aerodynamically unstable, it normally falls several feet away from the point of discharge but may be seen in or adjacent to an entry wound if fired at close range. The significance is very akin to the petal in shotgun discharges.

Alternatively, the shooter may elect to use grease to act as a flashover protector. Many substances are available. This material may be dispensed from a small grease gun or applied directly from the tin using a small spatula or stick. Again, in "close range" shots, finely dispersed grease may be seen on the victim's skin or clothing.

A further variable is the option of a fully loaded or a partially loaded chamber, with the "dead space" being taken up by an inert filler. The filler is a nonflammable granular material, which again may be deposited on skin or clothing in close range shootings. Polenta, the maize product, is a substance favored by many.

The gun powder used is frequently Fine Fine Fine grain (FFFg).This fine black granular powder is extremely explosive. Any fine spark may potentially cause an explosion, a fact well noted during practice or competition matches where all smoking is banned on the range.

As mentioned, the ignition is activated by the detonation of a percussion cap placed on the nipple behind the cylinder chamber. The spent percussion cap is ejected on recocking the hammer. The spent percussion cap may be an important find at the scene and may provide significant material evidence.

At the moment of discharge, a large volume of flame and blue smoke is emitted along with the projectile or packing. In the case of contact or near contact wounds, one can expect a large volume of dense black soot to be deposited on skin and clothing. There may also be a distinctive sulfurous odour emanating from the zone of deposition. At intermediate range, tattooing as seen in "smokeless powder" discharges may not be evident.

FFFg powder is super fine in quality and its explosive nature almost ensures complete combustion. Grease, however, may be finely dispersed as may the inert granular filler. The filler is often white or yellow in color and, because of its firm granular quality, may in theory cause tattooing.

The fabric disc is considered an evidential bonus. In cases of contact or near contact discharge, a meticulous search should be made for the patch in the deep tissues as one would do to retrieve the petal in cases of shotgun discharge.

The entry wound is otherwise nondescript, since in most cases, the projectile is geometrically spherical. An abrasion rim is usually present and well defined. Lateral splitting may be seen in some cases. The ballistics and tool mark expert, however, may be expected to examine the ball for the tell tale imprints of the compression rod.

As mentioned, these firearms are seldom implicated in suicides and homicides. In Australia, they are regulated under the Firearms Act and fall into either the long arm or handgun category. Several decades earlier, however, these weapons were available without license. As a result, an undisclosed number of unlicensed black powder pistols are present in the community.

Anecdotally, black powder pistols have been favored as a weapon of choice in motorcycle club gangs and have occasionally been seen by the forensic pathologist in motorcycle gangland shootings.

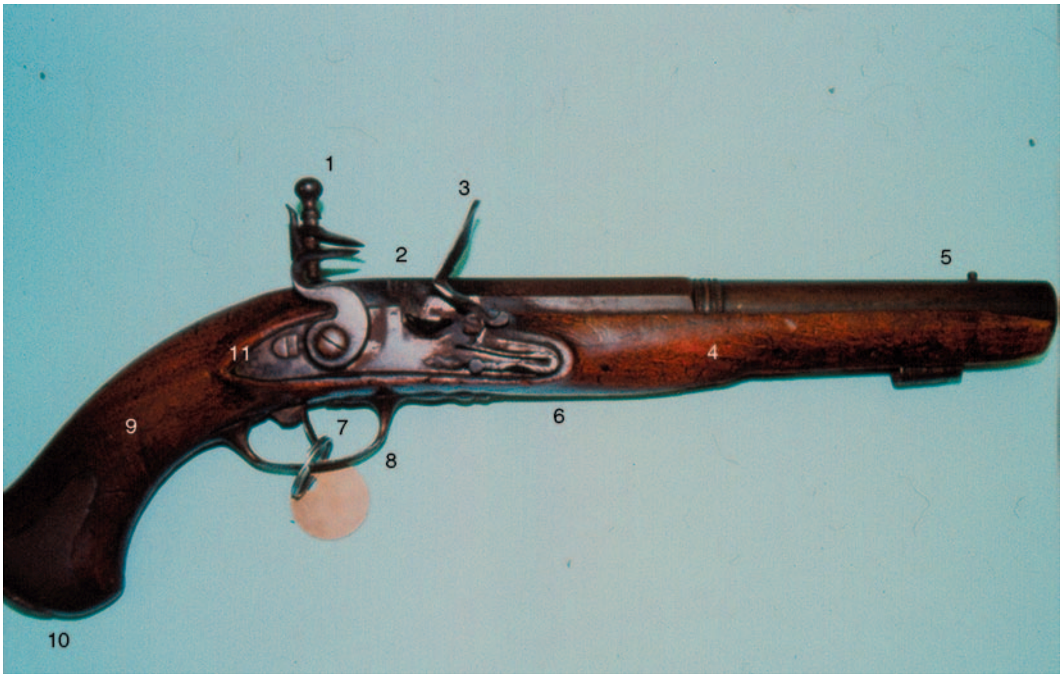


FIGURE 12.1A FLINT LOCK PISTOL (c. LATE 18TH CENTURY)

FIGURE 12.1B

FIGURE 12.1A Major components.

1 Top jaw and screw
2. Pan
3. Frizzen
4. Stock
5. Barrel
6. Frizzen spring
7. Trigger
8. Trigger guard
9. Butt
10. Butt cap
11. Lockplate

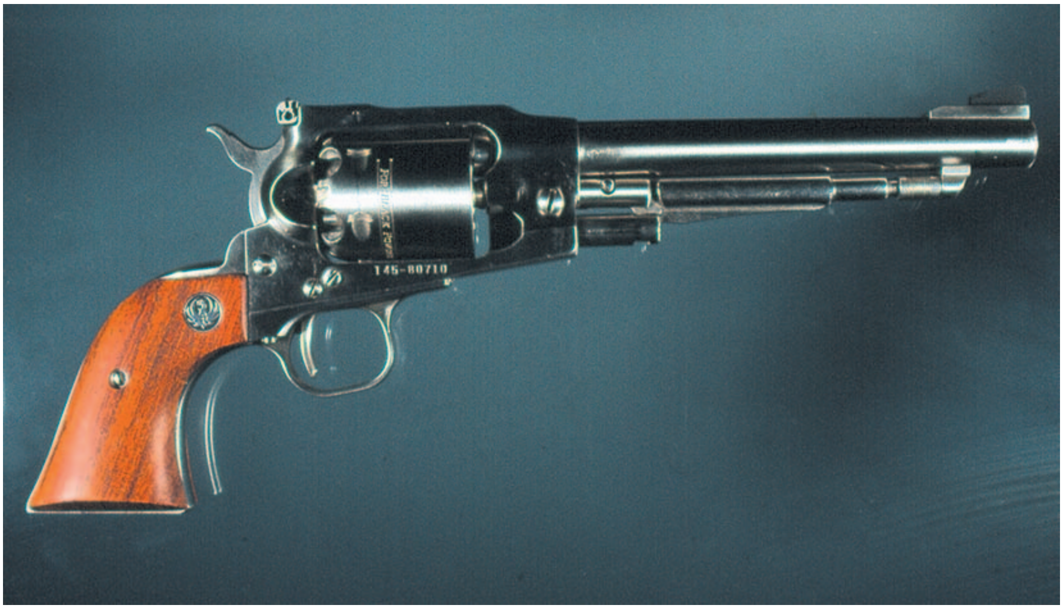


FIGURE 12.2 The author's Sturme-Ruger "Old Army" cap and ball black powder pistol — a fine example of precision engineering.

FIGURE 12.3 The paraphernalia of the black powder shooter. Note bullet mold, gun powder, and inert filler dispensers, projectiles, percussion caps, capping grease, and tray of accessories comprising cleaning equipment, powder funnel, and dispensing nozzles of varying volume.

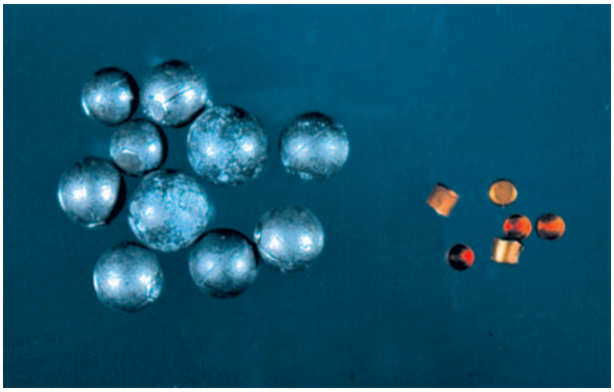


FIGURE 12.4 Unspent spherical lead projectiles of varying caliber. At right, unspent percussion caps

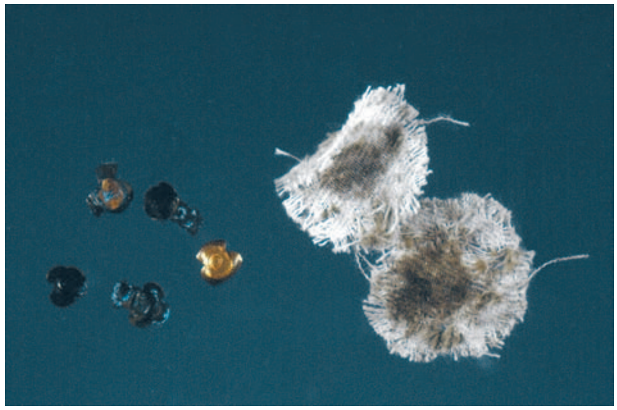
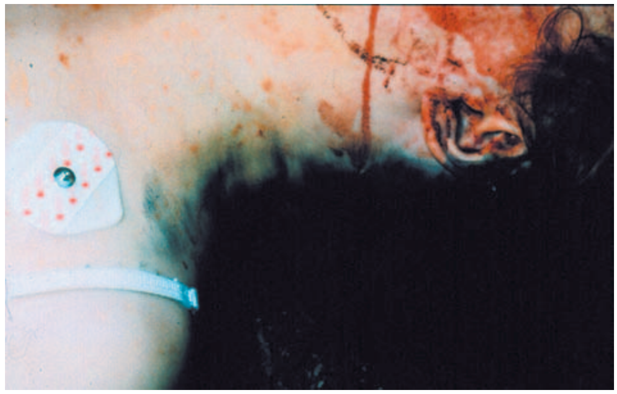


FIGURE 12.5 Spent percussion caps and fabric disks, if found at a crime scene, may constitute valuable evidential material.

A



B

C

FIGURE 12.6A, B, C Homicide involving a black powder pistol. Close range shot. A tangential entry wound is present on the left parietal scalp. Note excessive blackening and soot. Overall photograph of left side deposition over the entry wound of head, shoulder, and left ear. Soot deposition was very prominent in the surrounding hair (since shaved).

FIGURE 12.6D A closer view of the scalp entry wound. The bullet has entered at a shallow angle, creating a ragged anterior exit. The well-demarcated round central entry wound and leading edge of the linear laceration can be seen amid an ovoid area of intense soot deposition.

FIGURE 12.7 Another example of a black powder entry wound. Indeterminate range. Note round central defect with radiating splitting laceration.

13 Injuries from Air Pistols and Air Rifles

Fatal injuries from projectiles discharged from "air" powered weapons are exceedingly uncommon. Nonlethal injury is more commonly seen in patients presenting to the emergency department or general practitioner. The injury from a .177 cal. pellet impact is generally of little consequence to the victim. The penetration is often minimal; common sites include the limbs, buttocks, and occasionally the trunk. In many cases, local anesthesia only is required for extraction of the pellet. These injuries range from superficial trauma to the skin, subcutaneous tissues, and musculature to more serious injuries involving the face, neck, and eyes.

Eye injuries may range from nonpenetrating causing corneal ulceration and conjunctival trauma, to fully penetrating, with the more serious consequences of infection, lens trauma, disruption of retina and vitreous, and hyphaema formation. In rare cases, the pellet may pass through the eye and into the cranium. Fatality is more likely to be seen in infancy and childhood because the infant skull is thin and the squamous temporal bone offers little resistance to such projectiles travelling at near muzzle velocity. Projectiles of larger calibre (such as the 9 mm.) may cause more serious injury as the mass of the projectile is greater. The degree of trauma may resemble very closely that of a standard .22 rimfire projectile.

Intentional (homicidal) injury from a standard .177 cal. slug is exceptionally rare and most forensic pathologists will never see a case in the course of a busy professional lifetime. Readers who desire more information about fatal injuries from an air powered rifle are referred to Vincent Di Maio's book, *Gunshot Wounds* (1993), which outlines two cases of homicidal slug gun injury.

Pellets (slugs) are most commonly of .177 cal. and generally weigh 8.2 grain. This projectile is manufactured from soft lead and may be either spool or bobbin shaped (the Diabolo projectile) or cylindrical in configuration. The weight will depend on manufacturing specifications. Pellets of .20, .22 and 9 mm are also available although these calibers are less commonly employed.

Air powered weapons may be in the form of hand guns (pistols) or long arms (rifles). The barrel may be either rifled or of smooth bore type.

As indicated by the name of this class of weapon, these projectiles are expelled, very commonly, by the rapid expansion of compressed air. The pressure head may be developed by a pumping action, spring loaded cocking mechanism, or by the release of compressed air from a cylinder.

Many modern pistol shooters employ either a spring loaded mechanism or carbon dioxide gas. The latter may be contained in an underlugged cylinder or cannister below the barrel, which is filled from a larger storage cylinder or by the use of disposable soda siphon gas bottles. These more sophisticated weapons can expel the projectile at a muzzle velocity approaching 750 fps.

In comparison, its "toy" counterpart, the BB gun, releases its small .177 diameter steel ball at velocities of between 275-350 fps.

The target in standard air pistol competition is set at 10 m. Accuracy drops away markedly beyond this point and is certainly ineffective at 50 m.

The skin entry site is typified by a hole approximating the diameter of the pellet, although skin elasticity may reduce the diameter considerably. An abrasion rim may be seen. A small rim of discoloration may also be noted, due to transfer of fine lead dust and oil accumulated in the barrel.

The application of a drop of machine oil behind the projectile prior to trigger release causes a small explosion on expansion of the gas — a process called "Dieselling." This practice may theoretically accelerate a standard .177 projectile to muzzle velocities approaching that of a .22 caliber bullet. The following images outline the extent of injury commonly seen in usual practice.

FIGURE 13.1 The author's competition air pistol, a FWB C20. The pistol is powered by a carbon dioxide filled cylinder located below the barrel.

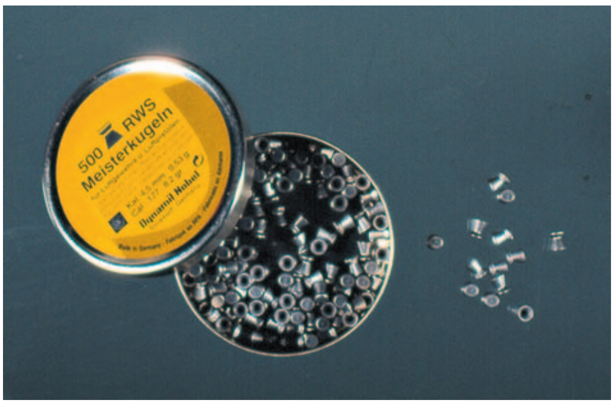


FIGURE 13.2 Air pistol pellets — .177 cal.

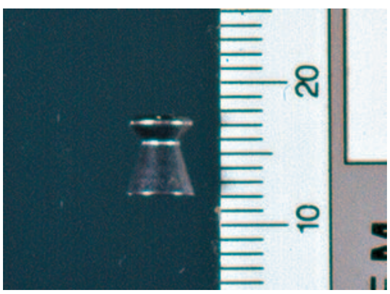


FIGURE 13.3 Inset — close view of typical projectile.

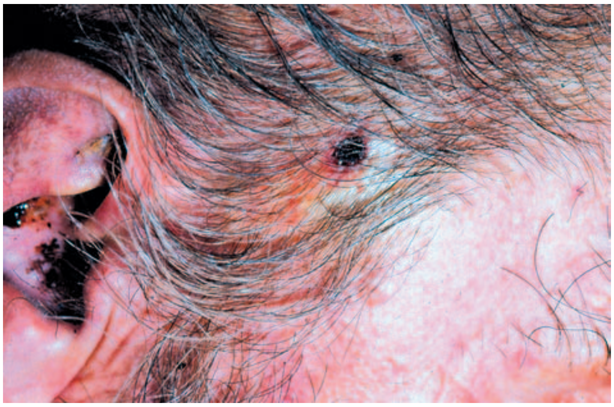


FIGURE 13.4A A typical air gun entry wound. The site in this case is the right temple. A small well demarcated defect is seen with a subtle abrasion rim. This injury was nonfatal.

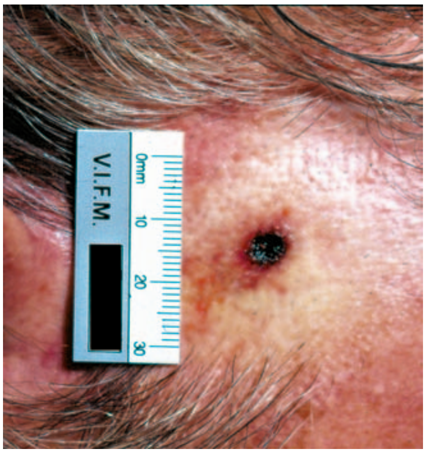


FIGURE 13.4B Area shaved. The deceased died of natural causes. The pellet did not penetrate the cranium.

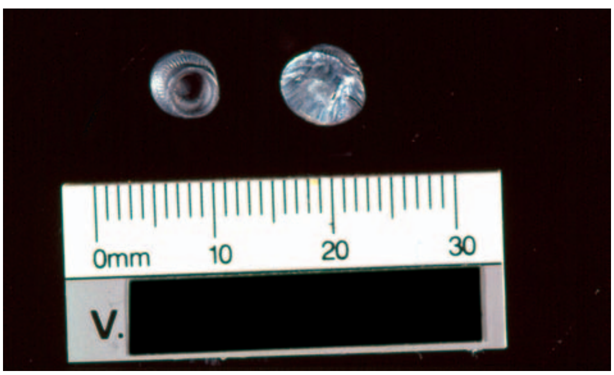


FIGURE 13.4C The above case proved to be a tandem shot. The two pellets are shown, one fitting the rear end of the other. The suspect gun was test fired and proven to be capable of delivering a tandem discharge.

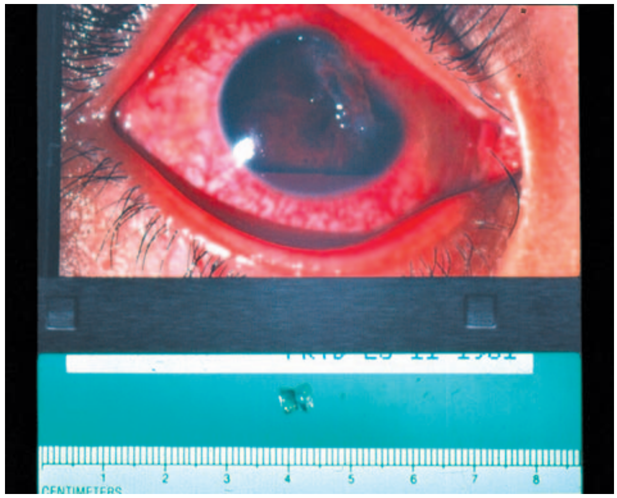


FIGURE 13.5 Intraocular trauma. Note the acute hyphaema, ciliary pattern of conjunctival vessel congestion, and corneal defect. The offending pellet is seen in the inset below.

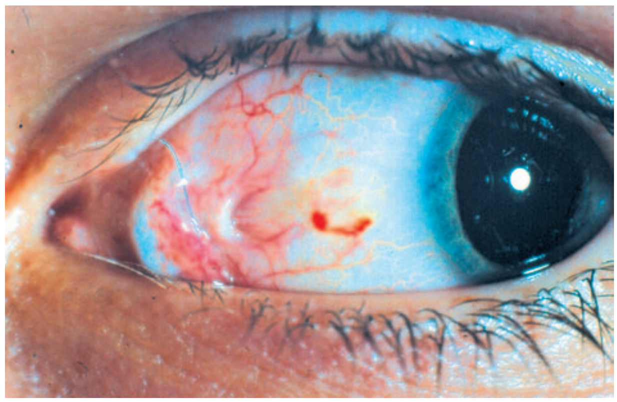


FIGURE 13.6 A healed penetrating injury of the conjunctival membrane. Note puckered scar and area of neovascularization.

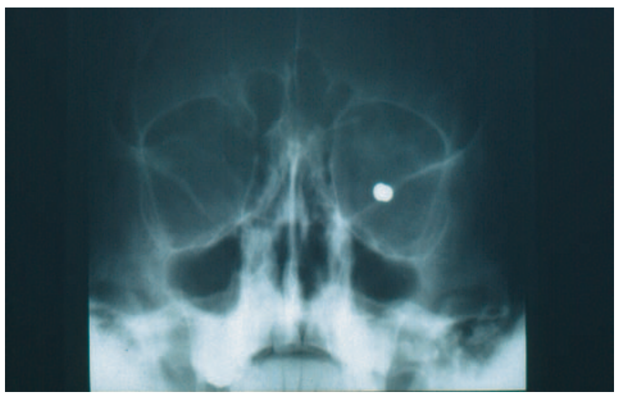


FIGURE 13.7 Typical radiological appearance of an intraocular .177 cal. pellet. The spool shaped projectile is readily identified.

14 Nail Gun Injuries

Nail guns are handheld industrial tools designed for mobile use on construction sites. Most resemble a hand gun in that they have a pistol grip and conventional trigger release. Larger tools designed for the firing of heavy nails (often contained in long magazines) closely resemble submachine guns. The smaller instruments are often powered by .22 caliber cartridges. Options also exist for air driven tools powered by gas cylinders or from direct supply links to compressors. All tools require direct pressure onto a front footplate before the nail can be fired. This facility ensures both safety in the prevention of accidental discharge and a perpendicular line of fire into the timber plank or board.

In a busy forensic practice, most cases will consist of suicides and accidental injuries, and fatalities resulting from impact from expelled nails or studs discharged from industrial nail guns are uncommon. However, the rare homicide may be encountered. If the tool is to be used as a casual "target pistol" or for criminal purposes, the safety plate must be depressed manually. Accuracy is poor over distance but sufficient to inflict serious injury by the very nature of the expelled projectile.

The nails are of conventional design, varying only in width, length, and metal composition. Most have an exceedingly sharp point. The cartridges used are generally of .22 or .38 calibre. The tip of the cartridge is often crimped or capped by a plastic plug. The powder load is generally color coded. Although the cartridges may be fired from conventional firearms, the load is generally too powerful for the cylinder and serious injury may result if this is attempted.

Most casualty departments or emergency rooms have been involved in the treatment of victims of accidental firings, the projectiles perforating fingers, hands, thighs, or feet. Poor work and safety practices account for the majority of industrial accidents. The author vividly remembers a case of a male admitted to the emergency room with a nail penetrating the lower mid chest. The protruding end of the nail was noted to oscillate in synchrony with the heartbeat.

The forensic pathologist will deal with the suicidal and accidental work place fatalities. The "sites of election" differ little from those seen in conventional firearm suicides. The mid forehead, temples, chin, and chest are most commonly involved. As the pressure plate needs to be depressed with some force, applying the plate beneath the chin or onto the chest creates some stability for firing. The entry wound is typified by a small round defect closely matching the thickness of the nail. Skin elasticity may create a pinhole sized defect that may easily be missed on initial examination, particularly in a heavily bloodstained field. If the plate is depressed manually, one can expect a well defined zone of blackening and focal searing.

The exit wound may range from a nondescript pinhole to a linear laceration. The ability of the nail to exit largely depends on the trajectory and its passage through dense bone. Radiology is mandatory, as the possibility of multiple shots exist.

Safety in the mortuary is also an important and often overlooked issue. Knowledge of the exact location and number of nails will avoid possible pricking of the fingers and metal to metal clashing of skull saw blades. A recent review of the literature strongly suggests that the presence of a bent nail almost invariably indicates an accidental shooting or ricochet.

The rapidity of death is site dependent. Because the projectile is sharp and slender, immediate collapse is often not seen, therefore increasing the likelihood of repeated shots in the case of suicide.

CASE 1

A 32-year-old depressed male shot himself with a single nail using a small handheld nail gun. The footplate was depressed by application against a fragment of plywood. The nail entered beneath the chin and travelled upward, piercing the tongue and hard palate. The nail passed through the brain in the midline and exited the vertex of the skull. Cerebral damage was minimal; no vital structures were damaged. A well demarcated muzzle outline was seen on the underside of the plywood. The skin at the entry site closely resembled a conventional .22 caliber contact bullet wound. The exit comprised a linear laceration. The vertex of the skull showed conventional external beveling with radial fracture lines. The major airways were filled with blood clot and there was considerable aspiration of blood into pulmonary parenchyma with prominent terminal congestion and edema.

CASE 2

A young child was killed by a caregiver. Two independent shots were fired, one each through the side of the head in the transverse plane, right and left respectively. In this case, the entry sites comprise a ragged ovoid defect, demonstrating the blast effect of the discharge. One nail exited completely; the other is seen protruding through the contralateral temple. Death in this case was immediate.

FIGURE 14.1 The nail gun used as a weapon of suicide. The nail gun was powered by a .22 caliber cartridge.

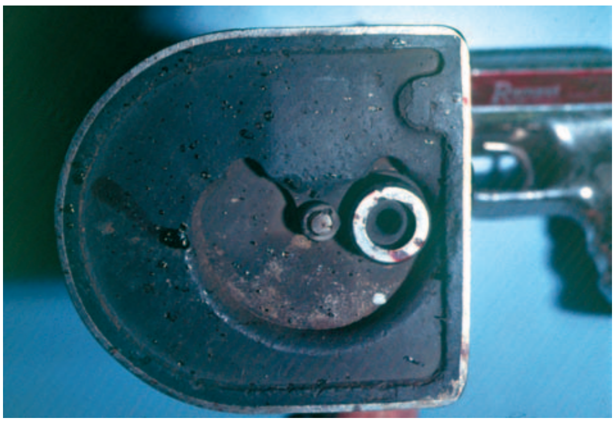


FIGURE 14.2 View of foot plate.

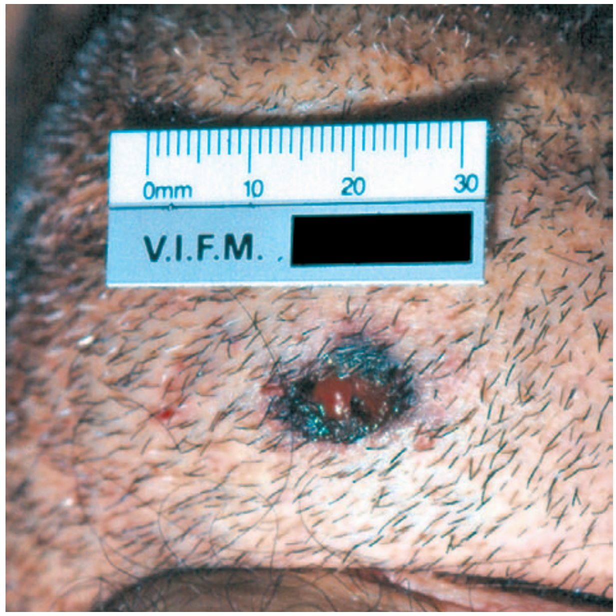


FIGURE 14.3 Entry wound beneath the chin showing nondescript defect with regional soot deposition.

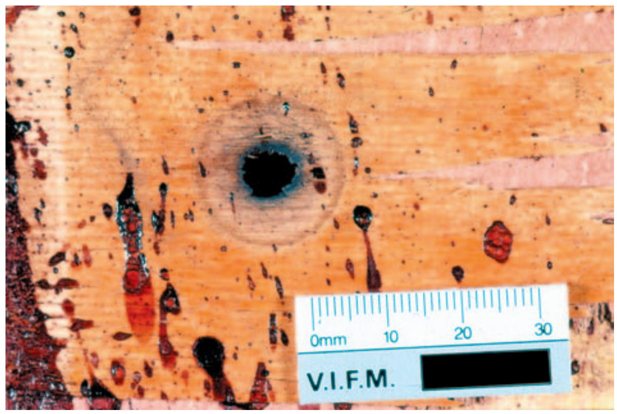


FIGURE 14.4 Plywood fragment placed beneath the chin and against the footplate showing a conventional soot deposition approximating the dimension of the muzzle.

FIGURE 14.5 Exit wound through the vertex of the scalp. Anteroposterior splitting lacerations are evident.

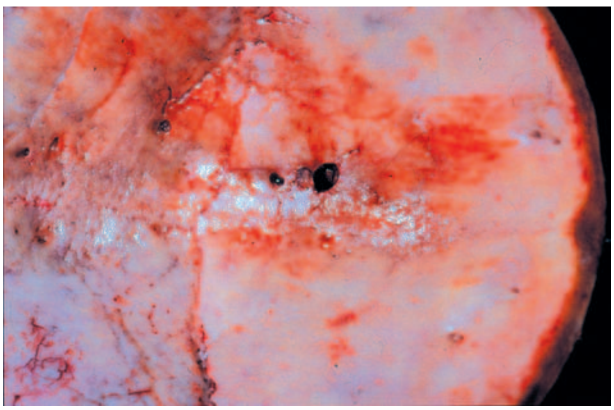


FIGURE 14.6 Entry via inner table of cranial vertex. An ovoid, well-demarcated, punched-out defect is seen.

FIGURE 14.7 Exit wound via cranial vertex. Note external beveling and radial fracture lines.

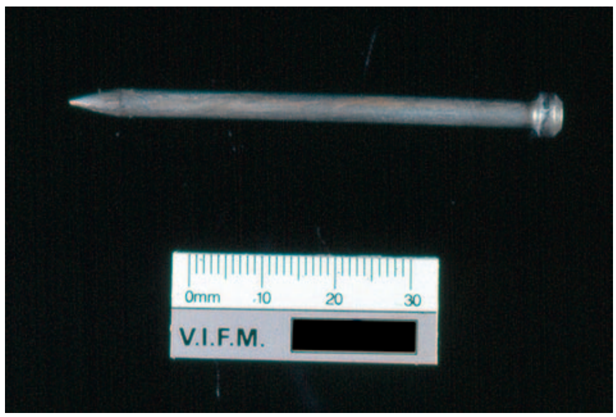


FIGURE 14.8 The projectile in question — a galvanized nail with sharpened tip and bullet head configuration.

FIGURE 14.9 Infant nail gun homicide. Right side of head. First entry wound consisting of ovoid defect with subjacent skull fracture.

FIGURE 14.10 Second entry wound with point of exit of first nail. Left side of head.

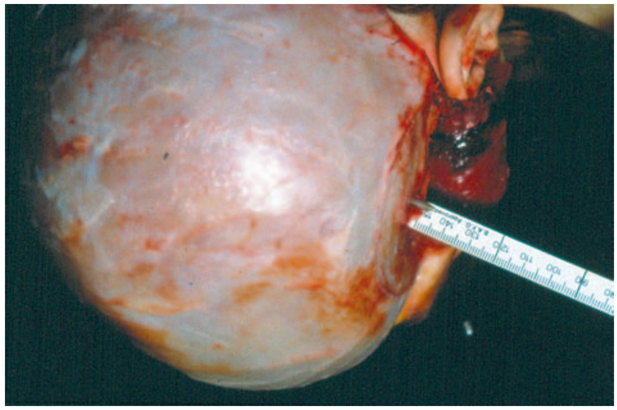


FIGURE 14.11 The scalp has been reflected exposing the protruding nail point.

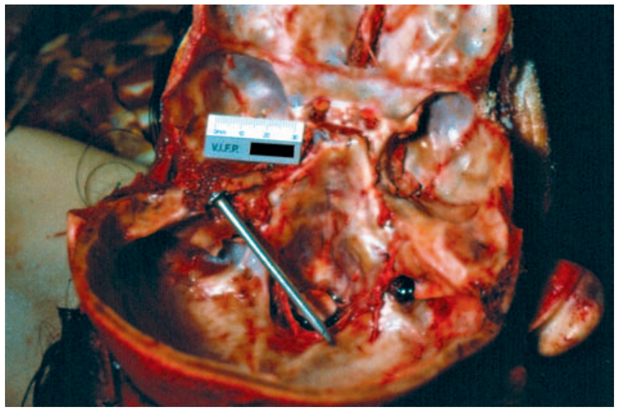
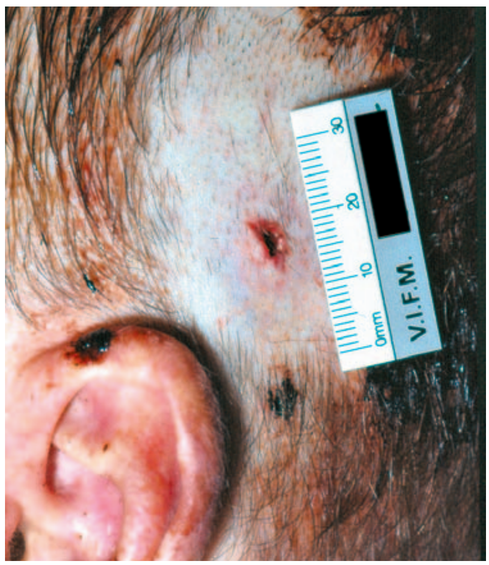


FIGURE 14.12 Intracranial view showing entry and exit sites. The nail has been placed inside the calvarium for size comparison.

A (right)



B (left)

FIGURE 14.13A, B A further sample of suicide by nail gun. The entry and exit defects (right and left temples respectively) are shown. There is little to distinguish this case from that of a typical .22 caliber shooting.

15 The Intermediary Target, Atypical Wounds, and Miscellaneous Gunshot Injury Patterns

This chapter deals with the more uncommon but occasionally encountered gunshot injury patterns seen by the forensic pathologist and ballistics expert. This aggregate of injuries includes those seen after the projectile has passed through a surface before hitting the victim (the intermediary target), atypical entry wounds (those of graze and tangential type), and the effects of bullet ricochet. These injuries cannot be dismissed as oddities of gunshot trauma.

The morphology and etiology of these injuries often present a dilemma to the examining pathologist. For example, does the injury constitute an entry or exit wound and can the direction of fire be reasonably determined? It is only through exposure to good examples of these injury patterns that an appreciation of the morphology and the mechanisms involved can be gained.

THE INTERMEDIARY TARGET

The intermediary target is an interposing surface that the projectile passes through during its flight from its passage from the muzzle of the gun to the victim. The nature of the surface is enormously variable. It may be glass (as may be seen in car or domestic windows), thin metal (as seen in a car door), wood (such as a door or partition), plaster board, or wire mesh. The effect on the projectile is immediate. The bullet may fragment in the true sense, giving rise to independent flying lead particles or the jacket may separate from the core. The true flight of the projectile is disturbed. The natural tendency of the bullet to wag or yaw is exacerbated.

It may be that stable flight through gyroscopic spin was not fully established in the case of close range shots. The bullet may tumble in an erratic fashion and may enter the target side-on, backwards, or in an oblique fashion. The net result is an irregular entry wound, not at all resembling the expected entry defect. The central defect may be ovoid, elongated, or frankly irregular, and may have an exaggerated or irregular abrasion rim. Secondary entry defects may be caused by smaller lead fragments, jacketing, or extraneous foreign materials such as glass or wood splinters.

The net effect of finely divided glass particles hitting the skin at high speed is the creation of a pattern resembling very closely that of an intermediate range shot. This is termed *pseudotattooing,* which may be striking in some cases, and may obscure sparse true tattooing. The result is predictable; range determination may be erroneous. High power magnification at the time of autopsy may disclose finely divided and powdered glass particles on and in the skin. Closer examination may demonstrate an admixture of unburnt powder particles (true tattooing) on a background of pseudotattooing.

This latter scenario is almost always restricted to the close range shot through window glass. The author has been involved in the investigation of a homicide where the first of three shots were fired through the side window of a car. The injury pattern strongly suggested that the victim was looking at the assailant at the time of discharge. The next two shots were fired at contact and near contact range respectively, as a *coup de grace*. The result was a complex pattern of two well defined close range entry wounds, pseudotattooing, true tattooing, and atypical entry wounds to the face and neck following projectile fragmentation.

In the case of shotgun discharges, the pattern may become quite complex. As the pellet aggregate hits the interposing surface, there is a gross scattering and dispersal of projectiles. This is similar to the scattering of balls on a pool table at the instant of the break. Pellets collide with each other, some deform or fragment, others will be entrapped within the intermediary matrix. The net result is premature dispersal of the pellets, resulting in a pattern on the victim that resembles a distant range shot. The explosive forces generated are often quite capable of blowing large chunks out of doors and walls. Secondary projectiles will naturally impact on the victim. The piston or wadding may be entrapped or deflected away from the target. Range determination at the scene becomes null and void. The "rule of thumb" can no longer be applied. Test firing later in the ballistics laboratory is the only satisfactory method of range determination. All variables (such as the nature of the interposing surface and its thickness) need to be addressed.

The human body can be regarded as an intermediary target. Indeed, in the case of high velocity rifle discharges, bullets may pass through one person to strike another. The final entry wound pattern to the torso can be greatly modified by the passage of the projectile through an arm, especially if a "defensive posture" is adopted by the victim.

The recognition of a defensive posture is valuable in an evidentiary sense and helps to recreate the scenario. This may test the forensic pathologist at the autopsy table. The limb may need to be manipulated to create the exact posture at the time of bullet impact. Post mortem rigidity is a great impediment; this maneuver may need to be attempted once rigor has passed.

ATYPICAL ENTRY WOUNDS

These comprise the *graze* and the *tangential* wounds. The *graze* type wound is created by the passage of the projectile across the skin surface, without causing any significant degree of penetration. The wound may appear as a shallow elongated gutter without involvement of deeper fascia or adipose tissues. In most cases, the wound is elongated and may have a degree of taper at each end that renders the defect almost symmetrical in configuration. The question of direction of projectile flight then becomes problematic.

The presence of peripheral abrasion rims in these wounds is quite variable. Occasional small skin splits may assist in direction determination. The wound may be slightly deeper at one end, but it cannot be assumed that this indicates either first contact or exit.

The *tangential* wound, as the term suggests, indicates that the projectile has impacted onto the skin at a shallow angle or tangent. These wounds may certainly be deeper than the graze; examination of the extension of the injury may indeed be of great help in determination of trajectory. These wounds tend to lose their symmetry and often have "blunted" contact ends and ragged or torn "exit" ends. The degree of tearing and splitting lacerations and their orientation can often indicate the direction of passage of the projectile. The skin may become " rucked up" or creased, causing "lightning strike" extended lacerations toward the point of exit.

High velocity tangential wounds may cause extensive tissue loss but reconstruction is often rewarding, with faithful directional tearing being demonstrated.

RICOCHET

A *richochet* is when a projectile is deflected from a surface and hits the victim indirectly. This is a rare event, and may only be seen once or twice in a professional lifetime. The bullet is generally required to impact with the surface at an acute angle for this to occur. The degree of angulation varies with the nature of the surface of first contact. The surface may be solid ground, a wall, an irregular object, or even water. The projectile may frequently deform and the jacket (if present) may separate from the core. Indeed, the jacket component may be the only object to strike the victim. Often the bullet remains more or less intact. Careful recovery of the bullet may demonstrate a smooth and polished edge indicating the surface of first contact. This phenomenon is naturally more pronounced in soft lead projectiles but may also be seen in fully jacketed projectiles.

The wound itself is nondescript and can resemble any of the patterns described for intermediary targets. The ricochet may also readily produce grazing or tangential wounds. The defining feature is a retrograde analysis of the scenario and close examination of the projectile by an experienced ballistics expert.

The following photographs indicate the range of injury patterns seen in this miscellaneous group.

FIGURE 15.1 A classic crime scene scenario resulting in injury from the passage of the projectile through an intermediary target. A shattered car window will readily produce pseudotattoing. The bullet frequently fragments, creating a complex injury pattern.

FIGURE 15.2 The injury complex nearest the scale represents entry points of individual bullet fragments and jacketing. The extreme zone of tattooing on the central facial area represents a further shot at intermediate range. A further shot has passed through the outer helix of the right ear.

FIGURE 15.3 A further example of a shot fired through a closed car window. The deformed projectile has entered the right cheek area. The arrow indicates an embedded lead fragment. Note irregular entry wound of the larger fragment with its wide abrasion rim. The crescentic area below the eye represents the impact of the rim of a pair of sunglasses. Punctate abrasions are obvious.

FIGURE 15.4 A complex pattern of graze and tangential injury after the passage of SG shotgun projectiles. The more superior injury constitutes a true graze.

FIGURE 15.5 A typical pattern of graze and tangential injury, mixed with typical entry wounds after a shotgun discharge. Note abrasion from wad impact.

FIGURE 15.6 Graze injury to the scalp 9 mm projectile. Homicide.

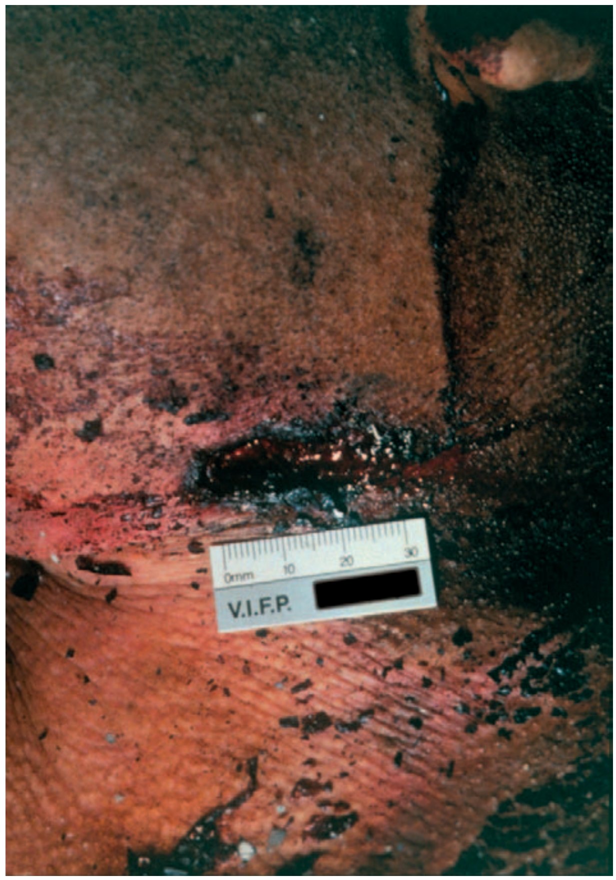


FIGURE 15.7 Tangential wound after discharge from a .38 Special revolver. Left side of neck. The direction of the shot is anteroposterior. Note regional blackening anteriorly with a trailing laceration posteriorly.

FIGURE 15.8 A deeper tangential entry to the occiput from a .9 mm projectile. Homicide. Splitting lacerations indicate that the projectile has passed from right to left (bottom to top of photograph). A well defined exit wound is seen immediately to the right, adjacent to the scale.

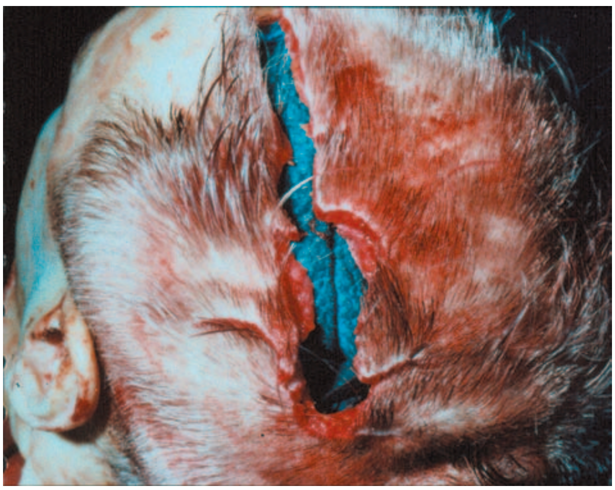


FIGURE 15.9 A tangential wound from a high velocity projectile fired from a hunting rifle. The initial entry point is represented as a gouged-out area. The trailing edge and splitting lacerations indicate that the bullet has passed from anterior to posterior.

FIGURE 15.10 A tangential discharge from a shotgun. The muzzle has been applied to the left anterolateral neck. Note sooting at the point of muzzle contact. The splitting lacerations indicate the direction of shot.

FIGURE 15.11 The body as an intermediary target. Initial entry to upper arm (round defect) with exit medially (elongated laceration). Reentry to left lateral chest. The second entry wound is now elongated with a wide abrasion rim, indicative of the bullet tumbling in an unstable fashion.

FIGURE 15.12 A further "through and through" injury complex. Determination of direction is problematic. The proximal graze and more inferior ovoid defect and penetration would strongly suggest that the exit is above the heel.

16 Illegal Modification of Firearms and Home-Made Weapons

The illegal modification of weapons is not uncommonly seen in crime scene work. Guns made "de novo" are less common. These weapons may be classified as:

1. "Cut down" shot guns to hand gun size
2. "Cut down" rifles to hand gun size
3. Hybrid weapons
4. Home made pistols
5. Home made shot guns
6. Pen guns

From the view point of the forensic pathologist and ballistics expert, there is very little difference in the injuries produced by both smooth bore and rifled weapons at intermediate and distant range. The trauma inflicted from a single solid projectile or shot pellet is essentially the same as would be seen from a discharge from a legitimate and unmodified firearm. Of great interest, however, is the occasional characteristic contact type gun shot injury caused by the firm application of the muzzle of a modified or home made firearm.

A crime scene investigator may suggest the use of a modified or home made gun by the muzzle imprint. This is particularly so in the use of a "sawed off" rifle, where the barrel has been cut through flush with the stock. This weapon may create a well defined muzzle imprint with an extended abrasion representing the sawed end of the stock or an excessively wide muzzle imprint representing the "proximal" end of the barrel.

A common example of a cut down weapon is the .22 caliber bolt action or semiautomatic rifle. When cut off at the stock, the bore diameter is often markedly smaller than the overall barrel external diameter when compared to the muzzle end of unmodified firearms. This is due to the gentle elongated conical configuration of the barrel.

The barrel nearest the action is always of solid design to accommodate the high pressures generated in the chamber at the instant of discharge. Centerfire cut down rifles are less commonly seen but may exhibit the same exaggerated ratio of external diameter to bore.

The hard contact entry wound of the sawed off shot gun is essentially the same as the conventional injury pattern seen from intact firearms. Studies have shown that reduction of the barrel length has little influence over the dispersion of pellets until approximately one foot of the barrel remains.

Clearly, examination of the injury patterns from a shot gun vary enormously and this is entirely dependent on the distance from the muzzle to the contact surface. Similar patterns will occur from discharge of unmodified weapons given sufficient distance between muzzle and target.

The caveat here is clear: test firing must be performed on the weapon in question, using ammunition comparable to that implicated in the case under investigation.

Home manufactured hand guns involved in homicide are relatively uncommon in Australia but would appear to be more commonly employed in the U.S., particularly in gangland and race related killings. These weapons are often referred to a "zip guns."

In Australia, the home made pistol is perhaps more frequently seen in cases of suicide.

Often the victim has had training in basic engineering and may possess metal turning skills.

Starting pistols may also be modified to accommodate small caliber cartridges such as the .22 long rifle or short rifle.

The firing mechanisms of home made weapons are often crude but effective. These items almost always lack true rifling of the barrel and therefore are technically smooth bore weapons. Distinctive tool marks still may be detected, however.

Typically, an irregular or unusual muzzle profile or outline may well be represented on the skin of the victim. Often the very geometric configuration is too exact to be explained on the basis of skin splitting from rapid gas expansion.

Hybrid weapons are rare. This term indicates a weapon being modified to accommodate and fire a cartridge or shell of another caliber. A good example is the 12 gauge shot gun that has been modified to fire a centerfire rifle or pistol cartridge such as .38 or .357 bullet.

Hard contact injuries may manifest as a 20 mm circular abrasion with considerable soot deposition, with a central concentric defect of dimensions equaling that of the discharged bullet.

The pen gun may be seen in cases of both homicide and suicide. These weapons may be made from conventional thick metallic pen cylinders or from prefabricated metallic tubing. The firing mechanism is often a single spring release causing a pointed nail end to strike the base of the cartridge. Almost invariably, the bullet in question is a .22 caliber long or short rifle round. Accuracy is poor over distance, but when fired in the context of intermediate or contact range, may be very effective.

The case of "pen gun suicide," as illustrated, highlights a real pitfall in the interpretation of gunshot injury. The diameter of the well defined skin defect is approximately 10 mm. It could be strongly argued that the projectile was of a .38, .357 or 9 mm caliber. An X-ray in this case showed a conventional deformed .22 caliber projectile. The explanation in this case is simple — the wound diameter is exactly that of the internal diameter of the end of the tube. The defect has been caused by the passage of the projectile and also the powerful injection of gases through the oversized bore.

Home made shot guns are uncommon in western civilizations, but may be seen in developing countries. The author has seen the blast effects of the crude home made shot guns of East Timor, known locally as ratakans. The injury patterns are essentially those of conventional shot guns. Often the pellet entry wounds may be somewhat irregular. The pellets in question may comprise gravel, amorphous metallic fragments, or crushed glass. The shot gun cartridge can be reprimed and black powder charged but often conventional lead shot is in short supply.

Forensic work in developing countries often poses many challenges in wound interpretation. In addition, the projectiles are often radiolucent and potentially can create a hazard during the autopsy procedure. In many cases, radiological facilities are not available.

FIGURE 16.1 Sawed off 12 gauge shot gun — action open.

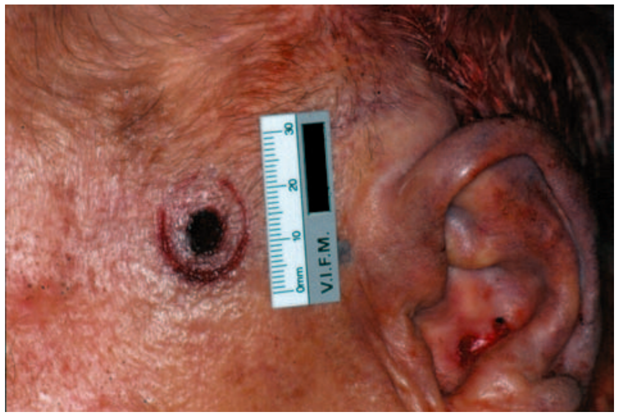


FIGURE 16.2B Well defined muzzle imprint to left temple.

FIGURE 16.2A Sawed off single shot bolt action .22 caliber rifle.

FIGURE 16.3A Sawed off .22 rifle.

FIGURE 16.3B View of sawed end of stock and barrel.

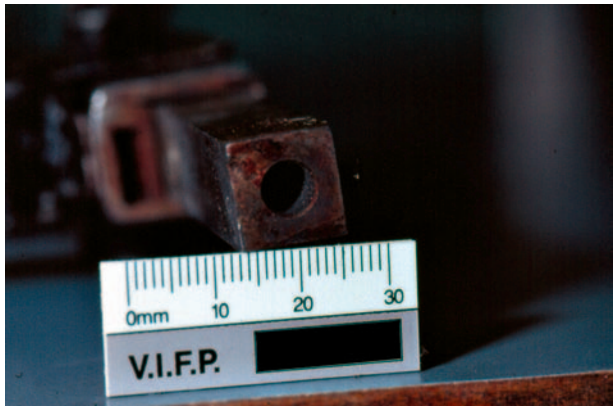


FIGURE 16.4A Home made .22 caliber pistol. Note muzzle configuration.

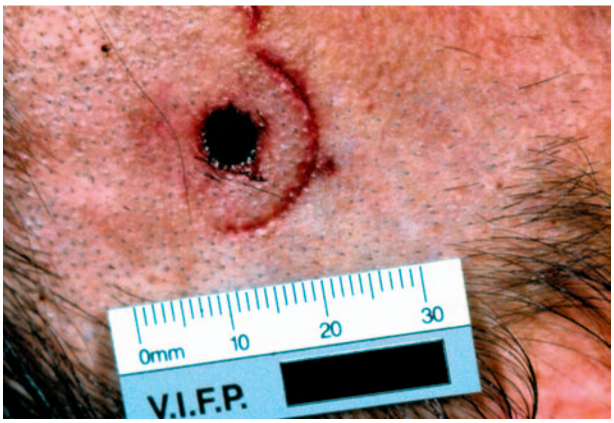


FIGURE 16.3C A well defined somewhat disproportionate muzzle imprint to right temple.

FIGURE 16.4B Geometric right angled muzzle imprint laceration to right temple.

FIGURE 16.4C Detailed view.

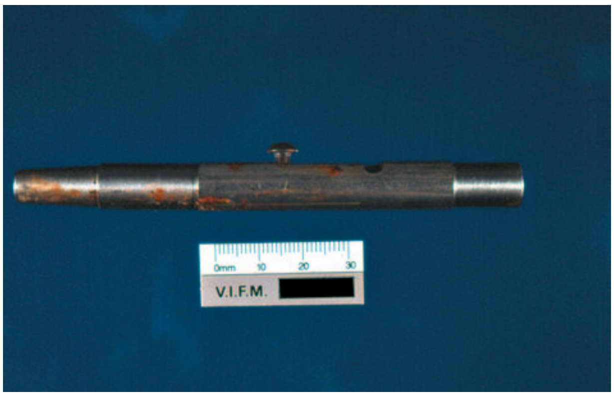


FIGURE 16.5A Home made pen gun accommodating a .22 long rifle cartridge.

FIGURE 16.5B Contact wound to right temple.

FIGURE 16.5C A 10 mm entry wound giving the false impression of bullet caliber. On first inspection, most examiners would suggest at least a .38 or 9 mm projectile had been fired.

FIGURE 16.6A Hybrid gun. Modified 12 gauge shot gun accommodating a .38 caliber pistol cartridge. A grip has been fashioned from a length of pipe welded to the action.

FIGURE 16.6B Action exposed. Note the sleeve like adaptor reducing the internal breech diameter from 12G to .38 cal. (bottom of photograph).

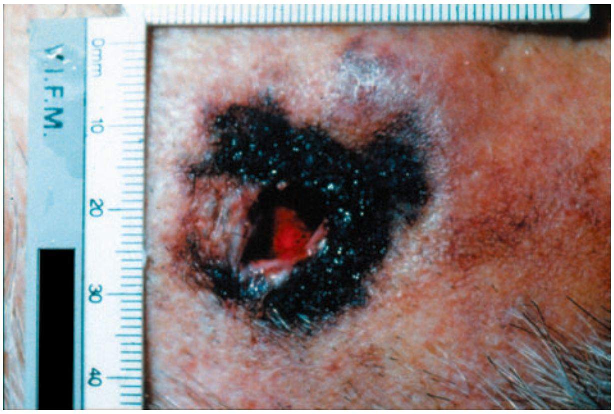


FIGURE 16.6C Complex contact entry wound with wide concentric sooting and central defect.

FIGURE 16.7A Reflected occipital scalp of a homicide victim. An unusual transmitted geometric bruise pattern from hard contact with a sawed off .22 caliber rifle.

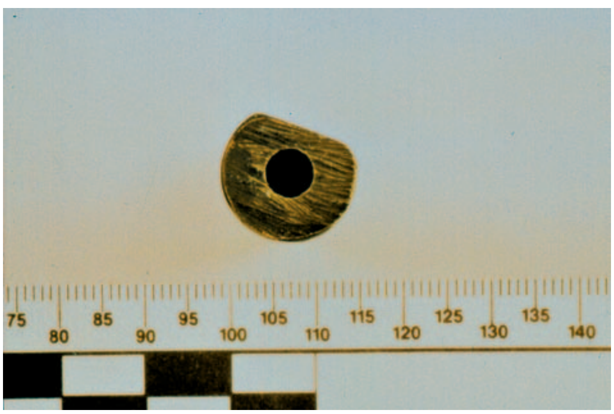


FIGURE 16.7B An exact match with the contusion and sawn off barrel.

17 Bone Injury, the Skull, and the Concept of Beveling

Bone, by its very nature, is a hard substance. In infancy, childhood, and early adult life, many bones have the ability to flex, bend, or deform. All, given sufficient stress, will fracture.

The injury patterns seen after the impact of a projectile through or into bone are of great significance to the forensic pathologist. The fracture patterns may faithfully indicate the direction of the passage of the projectile and in some cases, give a truly accurate estimation of the caliber.

The calvarium is composed of an outer and inner bony table and an intermediate layer called the diploe. At the moment of impact (site dependent), the projectile punches a hole through the outer table. The dimension of the hole may be that of the projectile or larger. The development of radial fracture lines from the central defect is quite variable and often dependent on the speed and size of the projectile, the bone density, and curvature of the skull at the point of impact. In the case of high velocity projectiles, the skull may literally explode, due to the massive supersonic forces acting on a rigid system. Recovered and reconstructed fragments may still reveal the site of impact. The exit point is often characterized by a "chipping out" of bone leading to a typical crater formation. This phenomenon is known as *beveling*.

Beveling will occur on the inner bony table of the skull on entry and on the outer table on exit. The concept of beveling is of the greatest importance to the forensic pathologist because it almost always provides accurate information concerning the trajectory of the projectile, whether it be examination of intact fresh bodies, the decomposed, or skeletal remains.

The internal bevel may also be seen in more dense areas of the skull such as the petrous temporal bone.

A concentric bevel surrounding the central defect generally indicates a perpendicular shot, while an eccentric bevel indicates angulation of the muzzle.

The following diagram illustrates in simplistic fashion the origin of outer and inner table bevel formation and thus, the deduction of bullet trajectory.

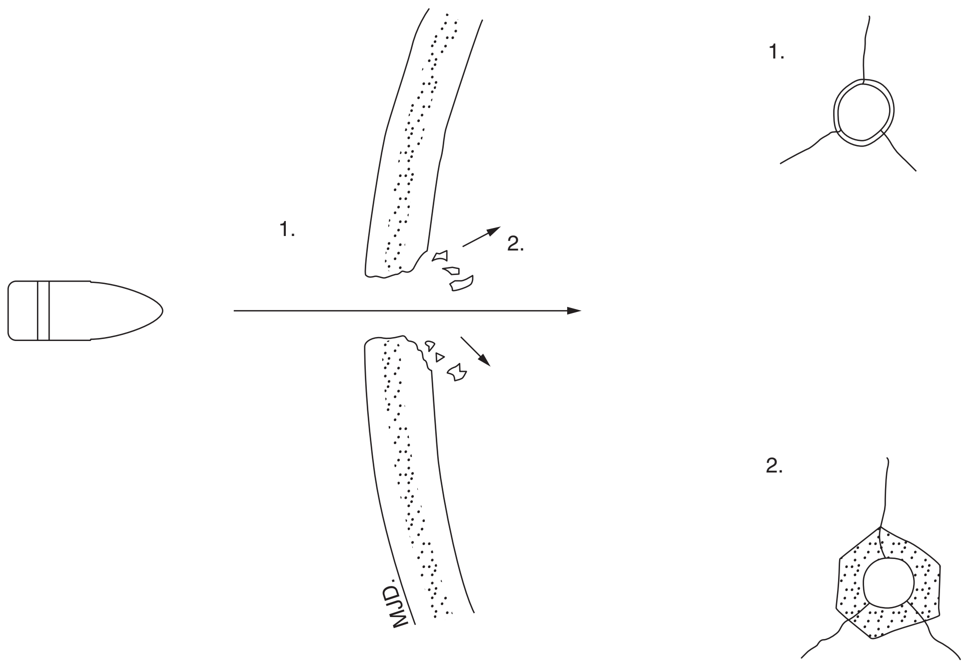


FIGURE 17.1

In cases of multiple gunshot injury, the sequence of shots may be deduced by *Puppe's rule*. Puppe's rule states that an extending fracture line will cease if it meets a preexisting fracture line or suture. Put simply, a bullet enters the skull causing a penetrating defect. Fracture lines may extend from the defect. A second penetrating shot may also generate new fracture lines. The second lines of fracture will cease abruptly if they travel and meet the first fracture line, thus the sequence of shots can be determined. This phenomenon may also be seen in cases of single shot injury.

At first glance, this may seem to be a contradiction. The generation and propagation of fracture lines over the calvarium may develop at speeds in excess of the passage of the bullet. This concept is adequately demonstrated in the case of an occipital external bevel interrupted by a fracture line taking its origin from a frontal entry wound in a single shot to the central forehead in the case of suicide.

In complex cases where the calvarium is highly fragmented, it is advised to deflesh the bone fragments and reconstruct them in a controlled environment with adequate time to contemplate the full circumstances of the event. This process can never be rushed.

The use of fast acting adhesives is recommended in "wet" cases; super glue or standard adhesive tape may suffice in the construction of dry skeletal exhibits.

The above discussion relates to the passage of the conventional solid projectile. In the case of smooth bore (shotgun) discharges, the pellets rarely pass through bone, rather they impinge, flatten or simply coat the surface. The massive destructive effects of contact type gunshot injury relate more to the rapid expansion of gas than the projectile impact per se. This is dealt with in greater detail in the chapter dealing with shot gun injury patterns.

Bones other than the skull may also show beveling. This is particularly so in the pelvic wings and sacral ala. Flat bones such as the scapulae may simply show an ovoid or circular defect with radial shatter. The reconstructed fragments may still show subtle beveling, however.

Ribs will frequently show a burst type defect, with spicules of bone demonstrating either outward or inward displacement. Vertebral bodies are prone to subtotal disruption, depending on bullet size and velocity. In many cases, bullets become lodged in the spongy centers of the vertebrae.

THE KEYHOLE PHENOMENON

The "keyhole" entry wound is frequently the *pons asinorum* of the trainee forensic pathologist. If a projectile enters the skull at a shallow angle or tangent, the entry defect may well be circular but with a leading edge of external chipping and bone loss. This is in part due to the lifting of bone from the leading edge of the defect from the outer table. External examination often strongly suggests an exit wound. If this is suggested early in the examination, before dissection and internal examination of the skull, erroneous deductions may be made with serious and often embarrassing results.

The inner table almost always demonstrates a conventional internal bevel. This finding puts to rest the question of direction. The bullet may exit the skull or remain *in situ*. Radiology is thus mandatory in all cases of gunshot injury.

A single shot to the head with bullet *in situ* on X-ray should resolve the problem prior to full dissection.

As in any case of trauma to the skull, diastasis may be seen in tandem with fracture, but this is more likely to be seen in the younger age group.

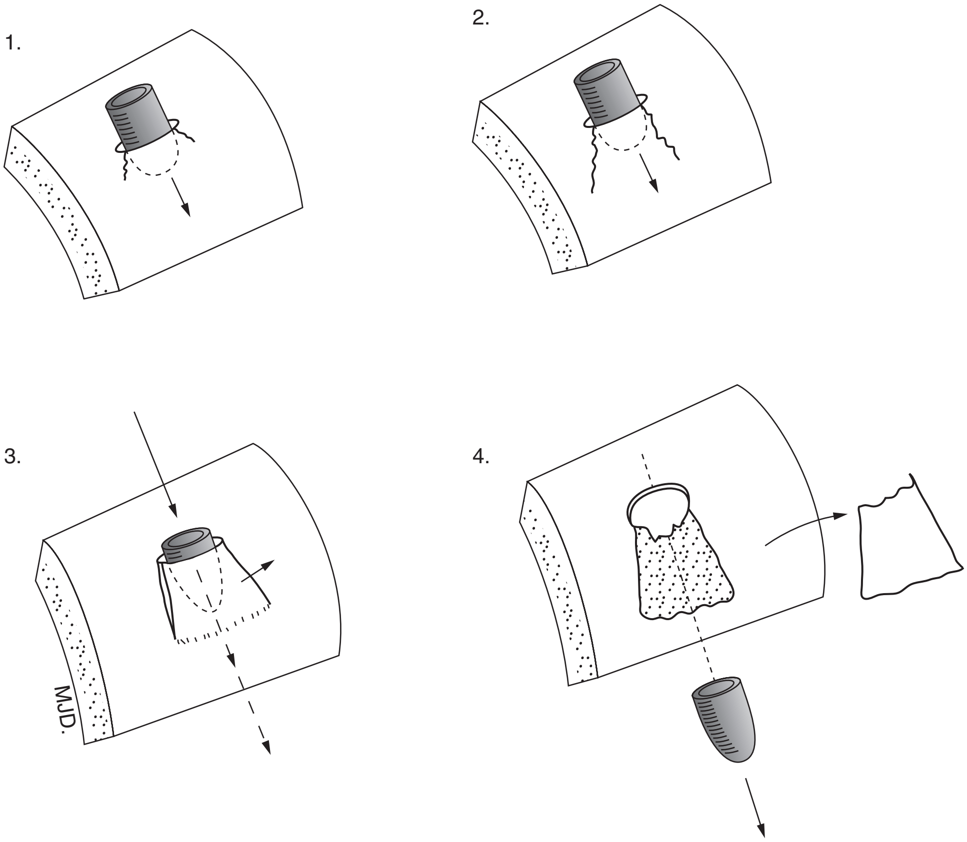


FIGURE 17.2 Explanation of the keyhole phenomenon.

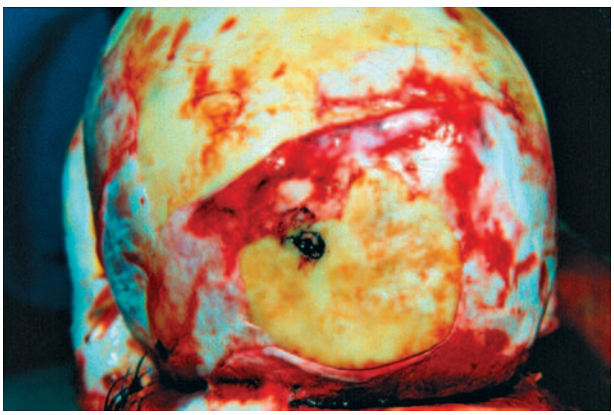


FIGURE 17.3A A typical contact type entry wound to the occipital skull. .22 caliber. Note metallic fragments on edge of defect. No radial fracture is present in this case.

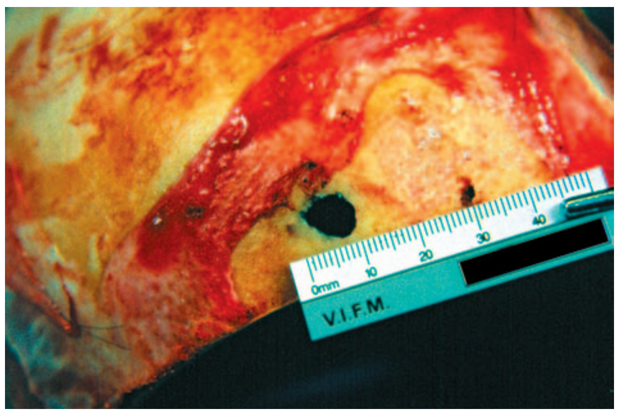


FIGURE 17.3B A close view of the typical contact entry wound shown in Figure 17.3A.

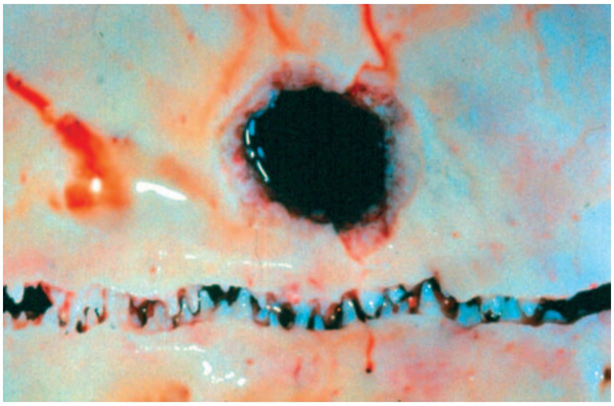


FIGURE 17.4 A bullet exit wound in an infant. Diastasis of an adjacent cranial suture is seen. .22 caliber.

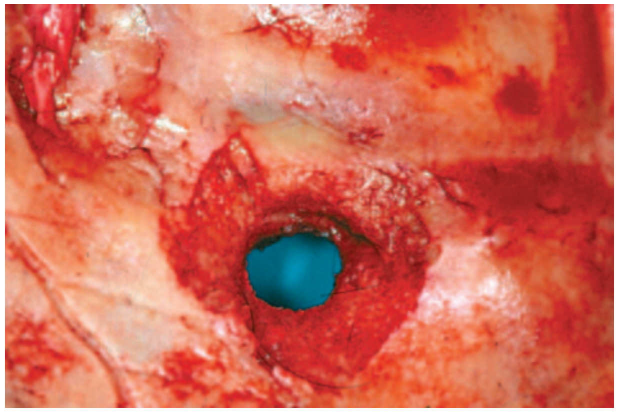


FIGURE 17.5C Close view of one of the bullet entry sites. Note well defined beveling. Neither bullet exited the skull.

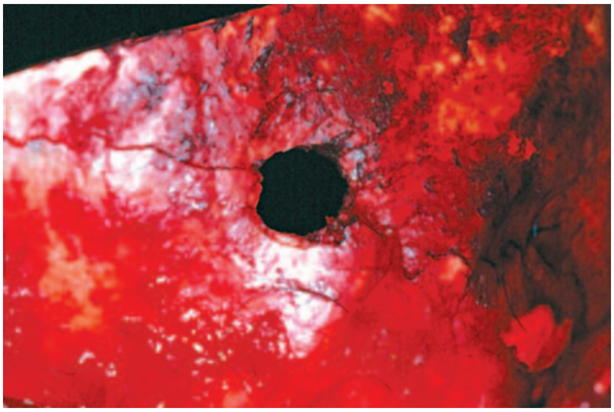


FIGURE 17.5A Entry wound — occipital skull. 38 special. Radial fracture present. Note the suggestion of external beveling. This may be seen in heavier caliber projectiles. Inspection of the inner table resolves the dilemma.

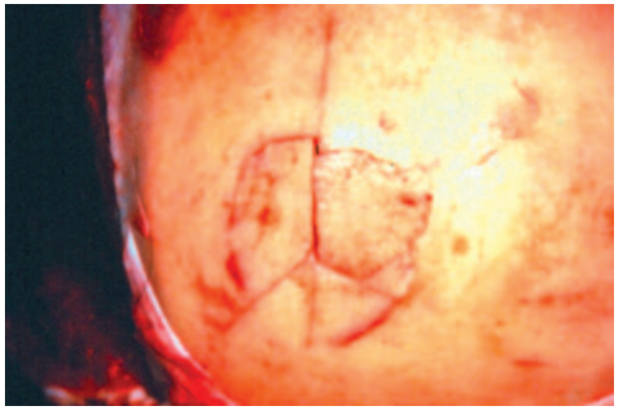


FIGURE 17.6A Circular and radial fractures in an incomplete exit .38 caliber.

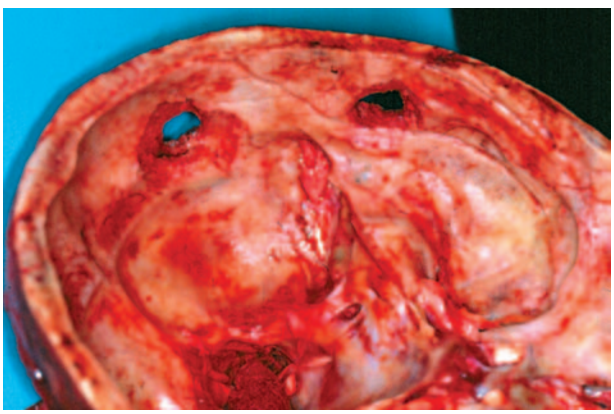


FIGURE 17.5B The occiput has two entry wounds.

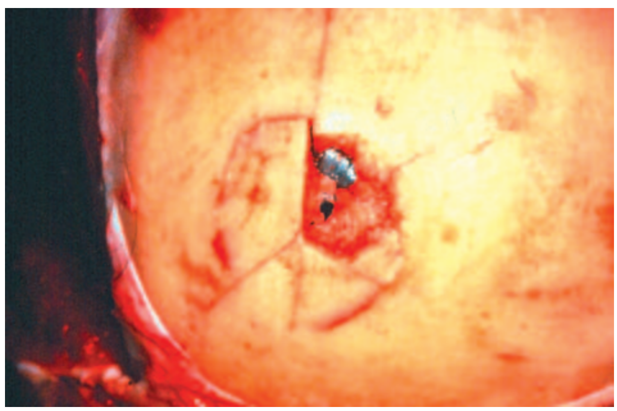


FIGURE 17.6B The projectile has lodged in the diploe and is visualized only after removal of fragments of the outer table.

FIGURE 17.7 A well defined bullet exit wound with radial fractures. The radial fracture at 6 o'clock has ceased abruptly with an oblique oriented fracture of the frontal calvarium.

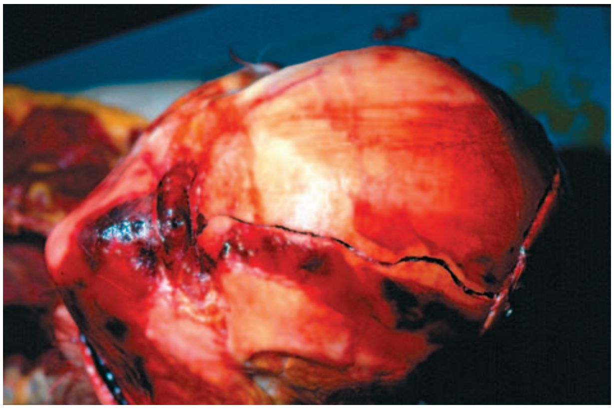


FIGURE 17.8A Single .22 magnum suicide gunshot to the mid forehead. Note fracture lines extending to the occiput.

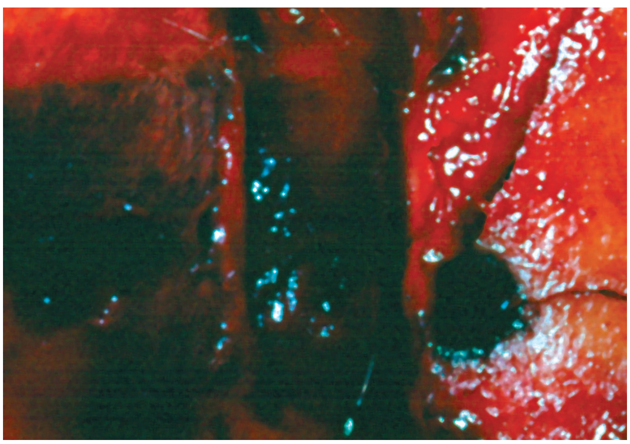


FIGURE 17.8B A close view of a central forehead entry wound. Note radiating fracture lines.

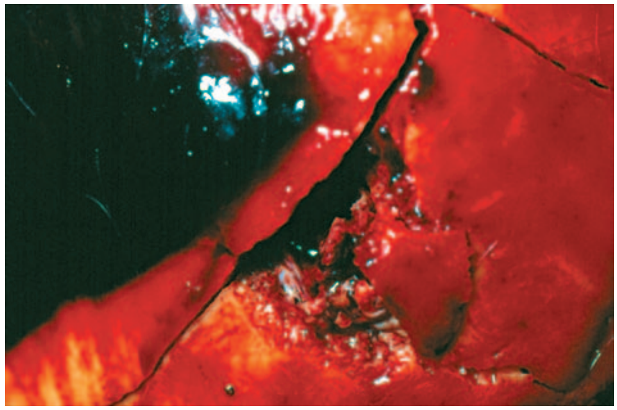


FIGURE 17.8C Incomplete exit point at the occiput. Note interrupted external beveling along a fracture line that has extended before the bullet has impacted with the inner table of the occiput.

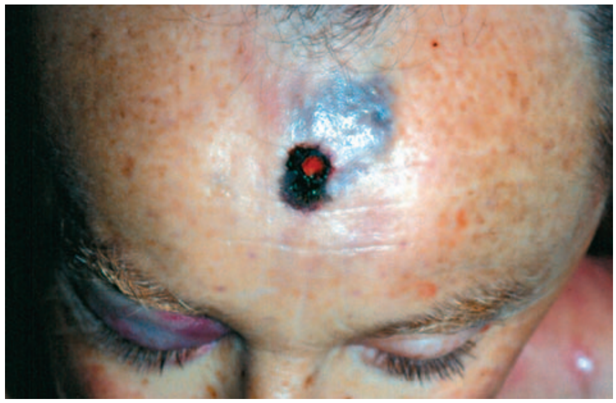


FIGURE 17.9A Contact type .22 caliber mid forehead suicide shot. The muzzle was placed at a shallow angle to the forehead. Note eccentric soot pattern and contusion extending to the vertex.

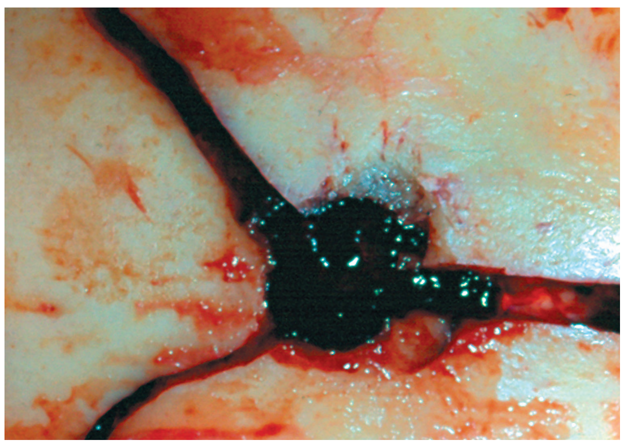


FIGURE 17.9B Note partial loss of external table on leading edge only. This illustrates the mechanism of the keyhole entry wound.

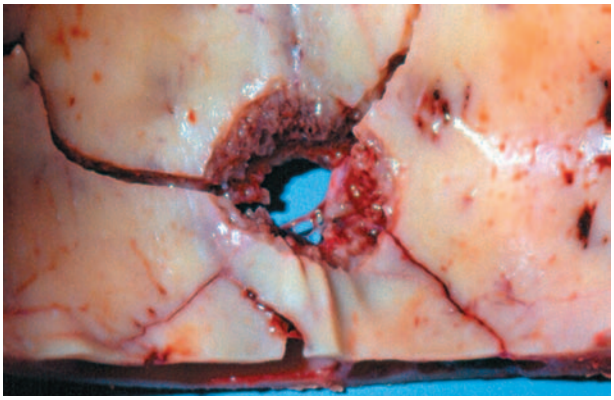


FIGURE 17.9C The appearances of the inner table showing well defined beveling resolving the question of entry in entry versus exit.

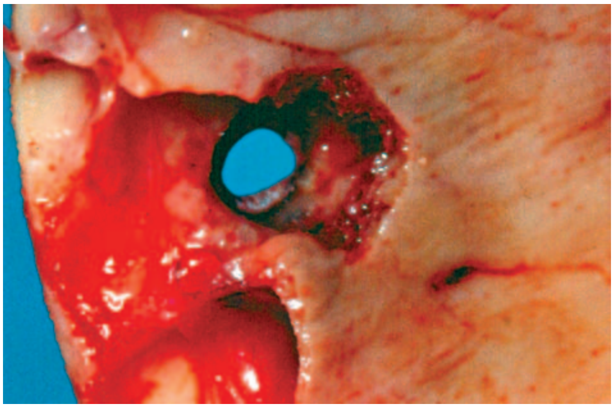


FIGURE 17.10A Well defined internal beveling — entry wound .22 caliber projectile.

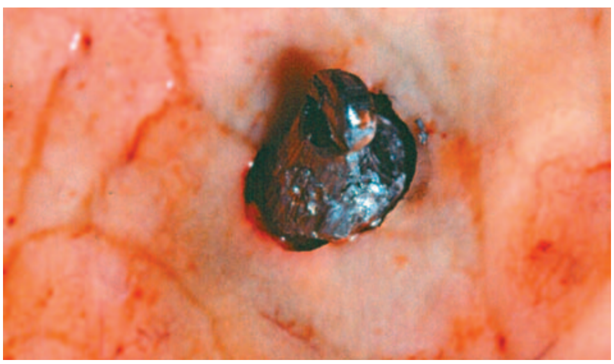


FIGURE 17.10B The bullet has deformed and impacted onto the contralateral inner table. Extraction of the projectile left a neat cavity — without radial fracture defect to the outer table.

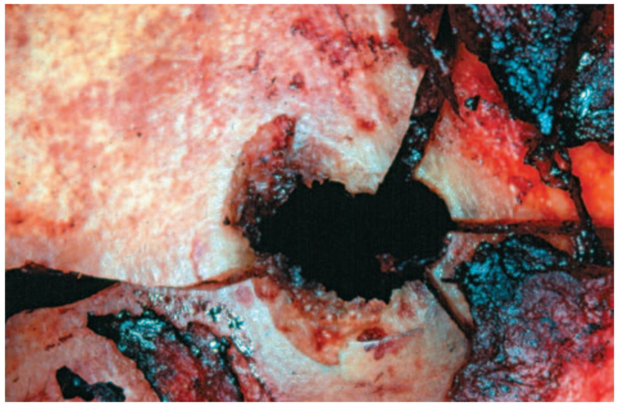


FIGURE 17.11 An excellent example of a keyhole entry wound. The bullet has passed from right to left at a shallow angle.

FIGURE 17.12 An extreme example of a tangential bullet entry wound to the vertex of the skull. The projectile has passed from right to left, causing massive bone loss and extensive beveling at the extreme left of the photograph. Note gougelike defect to the right. 7.62 caliber projectile.

FIGURE 17.13A Bullet entry wound to lateral aspect of the distal right femur. Note ovoid entry defect and loss of triangular fragments from medial surface.

FIGURE 17.13B The bullet has passed from right to left and has impacted on the medial edge of the left femur at approximately the same level. Triangular fragments are seen on the lateral surface, with minimal displacement.

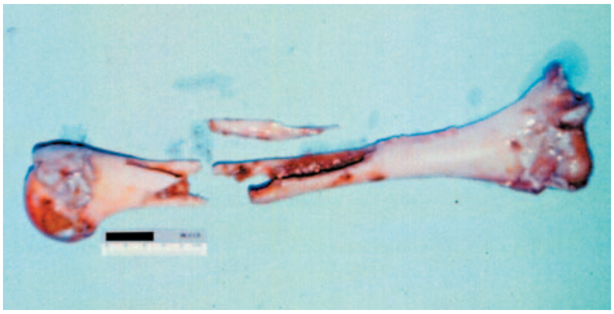


FIGURE 17.14 Typical high velocity gunshot trauma to mid shaft of humerus. 7.62 caliber distant range shot.

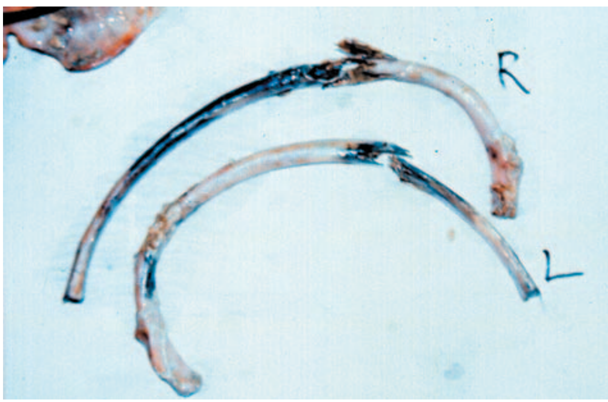


FIGURE 17.15 Rib fractures as a result of a high velocity gunshot injury. 7.62 caliber — distant range. The bullet passed through the torso in the transverse plane.

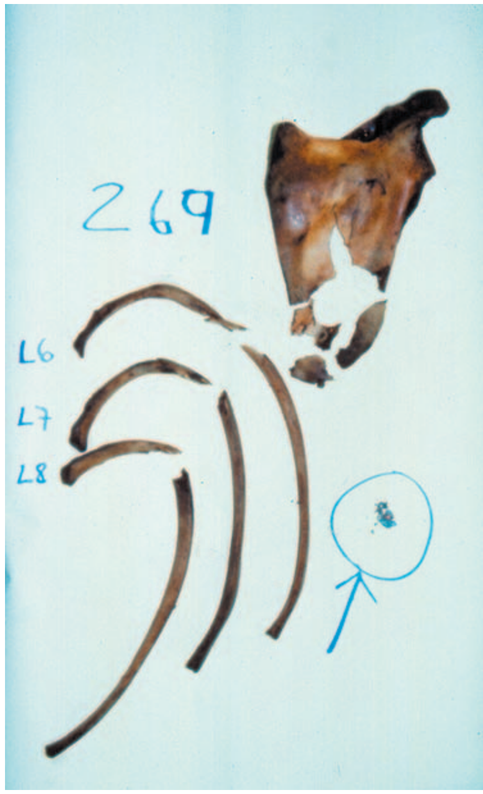


FIGURE 17.16 Fracture pattern of projectile passing through scapula and subjacent ribs. 7.62 caliber — distant range shot. The oxidized bullet fragments are encircled.

FIGURE 17.17A A further example of a tangential entry wound. Right forehead .22 caliber long. Homicide. Note near perfect circular interior defect with wedge–shaped superior extension.

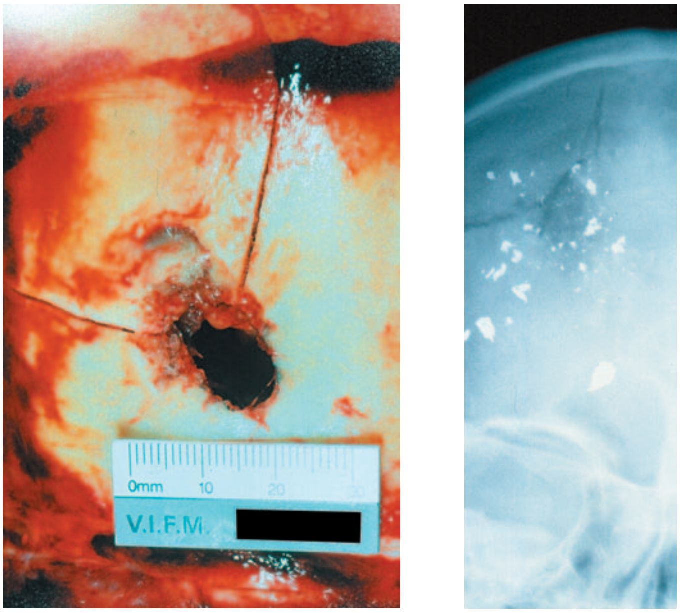


FIGURE 17.17B Scalp peeled back (left) revealing a keyhole-like defect to the outer bony table. There are two radial linear fractures. At right, X-ray of corresponding area.

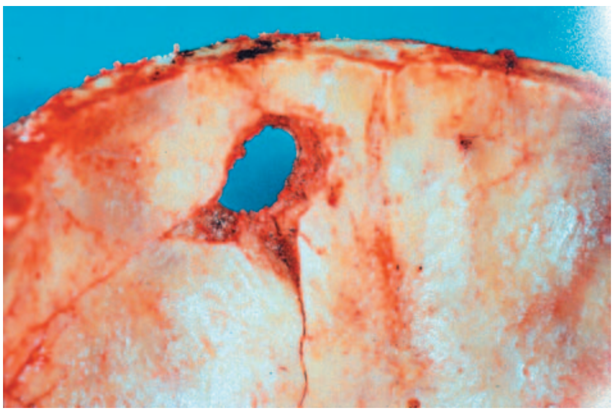


FIGURE 17.17C Note eccentric distribution of internal beveling with further extension along radial lines of fracture.

18 The Internal Organs

The accurate assessment and documentation of internal organ damage is of the utmost importance. It is not sufficient to document exit and entry wounds only, although these observations are vital in recreating the scenario of the shooting. Anatomical trauma needs to be well documented, and all information should be presented later in court in a succinct fashion so the jury can interpret the facts without confusion. The complete record will detail the entry, organs involved, and the exit in a progressive manner. The final comment should, without ambiguity, expand on the effects of the gun shot in simple and straight-forward terms. The forensic pathologist is prone to forget that the medical report will need to be read, and correctly interpreted, by nonmedical personnel.

One of the most important considerations in the assessment of a shooting is the concept of survivability, or put another way, determining whether the victim of the shooting could have been capable of any purposeful action after the impact of the projectile(s). Not all gun shot injuries are immediately fatal. Even after incurring several direct shots to the heart, the victim will theoretically have some 15-20 seconds of cerebral oxygenation, sufficient to act in a physical manner. Many cases are on record where a shooting victim has had the capacity of running from the scene, seeking help, returning fire, or inflicting injury to their assailant, even after suffering what would first be considered an immediately lethal injury. This latter function is often of great importance to the defense counsel.

Massive injury to the brain or brainstem are deemed to be more or less immediately fatal. Injuries to the spinal cord may render immediate incapacity for movement.

THE MECHANISMS OF CAUSATION OF INJURY

In general terms, and for the sake of prevention of repetition, there are essentially three basic mechanisms of injury.

1. *Low Velocity Single Projectiles* pass through internal organs by pushing their way through them. There is little in the way of cavitation formation, unless the muzzle is in hard contact position. The organ often cited as an example is the liver. The bullet passes through the liver in an uninterrupted fashion, creating a hole and passage of diameter closely matching that of the projectile. This is also true for organs such as the brain, lung, spleen, and kidney. The internal margins of the track may be somewhat friable and are frequently blood filled. Bullet fragmentation and jacket separation will also modify the track.
2. *High Velocity Projectiles*, by contrast, literally "smash" their way through. The projectile is travelling at or beyond the speed of sound and will likely cause a temporary cavity to be formed. The physics involved relate to an advancing wave of compressed air. The cavity may be up to 40–60 times the diameter of the projectile and may persist for several milliseconds. The cavity then collapses leaving a ragged irregular defect representing the passage of the projectile. Kinetic energy is expended by causing further dramatic disruption radial to the projectile track. This is especially so in organs such as the liver. The post mortem examination will demonstrate much pulping and fragmentation of the parenchyma. In some cases, a well defined bullet track may not be identified.
   In hard or near contact shots, there is also the consideration of large quantities of hot gas under extreme pressure. If the bullet is of soft point design, it may fragment almost entirely, creating the classic "lead snow storm" pattern on X-ray. If the projectile is fully jacketed, it may readily exit the body with little if any deviation in direction. Secondary projectiles may be set into motion and may exit independently of the bullet.
3. *Smooth Bore Discharges* may have an explosive effect if fired from contact or close range. The pellet aggregate exits as a solid mass but readily separates after passage through skin and muscle. The pellets then spread in a forward but often random fashion, ripping all tissues in their path. Coupled again with the massive release of hot gases under extreme pressures, resultant soft tissue damage is enormous.

The following discussion will now take into consideration the major organ systems. The reader should keep in mind the aforementioned information and visualize the trauma under these consecutive headings.

THE MAJOR ORGANS SYSTEMS

1. Central nervous system — the brain and spinal cord
2. Cardiovascular system — the heart and great vessels
3. Respiratory system — the lungs, major airways, and the hemithoraces
4. Gastrointestinal tract — the hollow viscera and the liver
5. Genitourinary system — the kidneys, bladder, and reproductive organs
6. Reticuloendothelial system — the spleen

Central Nervous System

The *brain* is a soft organ with little in the way of supporting connective tissues. The intraparenchymal vessels tend to hold the organ together to a certain degree. Bullets may pass through the brain leaving a well defined track or may cause massive pulping, or indeed total or subtotal exenteration. Impact to vital areas such as the brainstem may cause instantaneous death. The projectile may rebound from the inner table of the skull and cause extended damage by internal ricochet.

If cardiac output is maintained for any length of time, massive bleeding will occur. The bleeding is likely to be subarachnoid and intraparenchymal/intraventricular in distribution. If the projectile hits a nonvital area such as the frontal lobe, death may be delayed. The victim may succumb to the effects of cumulative internal bleeding and cerebral edema. If one survives, delayed complications such as epilepsy, meningitis, and profound retardation may result. Alternatively, the concussive force from a bullet hitting a nonvital area may be sufficient to damage the brainstem. Petechial haemorrhages within the brainstem are often demonstrated at autopsy.

Bullet tracks at autopsy often contain small bone fragments and very frequently, fine lead particles that are readily demonstrated on X-ray.

The spinal cord may be either lacerated, transected, or contused, resulting in varying degrees of motor and sensory dysfunction.

Cardiovascular System

The single projectile may graze the epicardium and myocardium or may pass through the heart. If the chambers are perforated, blood will be released under pressure and enter the pericardium or hemithoraces. As mentioned, a direct shot to the heart may not be immediately fatal. The victim may have some capacity for retaliation or defense for a short period. Low velocity projectiles may enter either the right or left ventricles or the atria. The left ventricular wall is much thicker than the right. Because of the supple and elastic properties of muscle, the defect caused by the bullet may indeed act as a valve. In spite of the greater pressure differential on the left side, in many cases less blood will be lost internally than from a perforating shot to the right ventricle. The comparatively thin right ventricular wall may tend to gape and therefore release more blood although under less hemodynamic pressure.

High velocity rounds and smooth bore discharges at close range will frequently cause massive destruction, often typified by pulping and laying open of all four chambers. Blood pools into the chest cavity (hemothorax) and may be in tandem with lung perforation and collapse (hemopneumothorax).

Occasionally, the projectile may graze a coronary artery leading to the formation of cardiac tamponade in the form of a hemopericardium. The *aorta* is an elastic organ in the young, becoming calcified and often brittle in the aged. Low velocity projectiles may readily pass through it leaving small slitlike lacerations. High velocity projectiles and smooth bore discharges may destroy the aorta in a catastrophic fashion. The ends may appear shredded and widely separated. If the aorta is the only significant organ damaged, there will be extensive internal blood loss resulting in hemodynamic shock and death. The hemorrhage may accumulate into a preformed cavity (the hemithoraces) or the retroperitoneal soft tissues, the latter often resembling the aftermath of a ruptured aneurysm.

Respiratory System

In an “uncomplicated” injury to the trachea, blood readily enters the lumen, which may then be further inhaled into the minor airways. Death may result from suffocation through aspiration of blood and ultimately, pulmonary edema. The trachea may also shatter, given sufficient projectile velocity and impact pressure.

Single low velocity projectiles tend to cause well defined holes through the visceral pleura of the lung and may or may not exit. There is often extensive intraparenchymal hemorrhage and again, often florid edema. The formation of a tension pneumothorax or a hemopneumothorax is commonplace.

The pulmonary parenchyma, in contrast to the brain, contains abundant supportive connective tissues and is naturally a highly vascular organ. Death may not be immediate. Gun shot wounds to the chest, involving lung only, are frequently salvageable following prompt surgical intervention.

Gastrointestinal Tract

The liver has been mentioned in passing and is often cited as the “organ of example” in many texts. The .22 caliber projectile often leaves a well defined track with somewhat friable internal margins. In many cases, “beveling” may be seen at the point of exit, especially if the liver is hardened by disease. Hepatic injury only may lead to slow internal haemorrhage and is often amenable to immediate surgical intervention. High velocity and smooth bore discharges tend to pulp the tissue, leading to massive blood loss, cardiogenic shock, and death. Large areas of cavitation and splitting lacerations are commonplace. The liver, by its very nature, tends to be brittle, as every surgeon will attest. Liver emboli may be seen in pulmonary vessels at autopsy and especially after histological examination.

The hollow viscera (stomach, intestines, and gallbladder) may all be perforated by the ”uncomplicated” passage of the projectile. The entry and exit points are nondescript. Survivor victims may demonstrate focal serosal and mesenteric hemorrhage surrounding the defect.

Because of the anatomical distribution of the large bowel and small bowel loops, it is not uncommon for multiple entry, exit, and reentry defects to be demonstrated at autopsy. Death is rarely swift unless major vasculature is traumatized. Without surgical intervention, death from peritonitis is the likely outcome, often several days later. Again, high velocity and smooth bore discharges can cause gross disruption to these structures.

Genitourinary System

The kidney, for all intents and purposes, behaves in much the same way as the liver. Although somewhat less likely to pulp, splitting lacerations with massive hemorrhage can be expected. The kidneys are retroperitoneal organs. Hemorrhage is often extensive but often largely confined within the fatty and connective tissues.

The bladder is protected by the bony pelvis but is prone to perforation if distended by urine. Secondary bony projectiles are likely to perforate the muscular wall of the bladder should the pelvis be shattered by bullet impact.

The uterus is occasionally involved in gunshot injury. Naturally, in the gravid uterus, the organ is more prominent. Many cases of intrauterine gun shot injury resulting in both maternal and fetal death are on record.

Reticuloendothelial System

The spleen is a solid but fragile organ and is prone to both pulverization and splitting laceration. The spleen is a vascular organ and likely to lead to massive hemorrhage if disrupted. The hemorrhage is intraabdominal. Trauma may involve nearby structures such as the pancreas, stomach, and diaphragm. In high velocity and close range shot gun discharges, the trauma may be such that the spleen may be shattered entirely and be rendered virtually unrecognizable.

REMOTE EFFECTS

On rare occasions, bullets may embolize. This is theoretically possible after trauma to highly vascular organs such as the liver or where large blood vessels such as the aorta (and major branches) and vena cavae are involved. The bullet may be seen on X-ray in a location well away from the expected point of rest. With sufficient “vis a tergo,” bullets may be swept along arterial or venous ramifications.

A bullet entering the aortic lumen may be swept into a common iliac artery, later to impact and occlude the popliteal artery. Tissue fragments (soft organ parenchyma, bone marrow and bone spicules) may also readily travel to distant locations. The immediate and long term effects vary with the organ of final impact.

The following photographic examples demonstrate some of the injury patterns seen in common forensic practice.

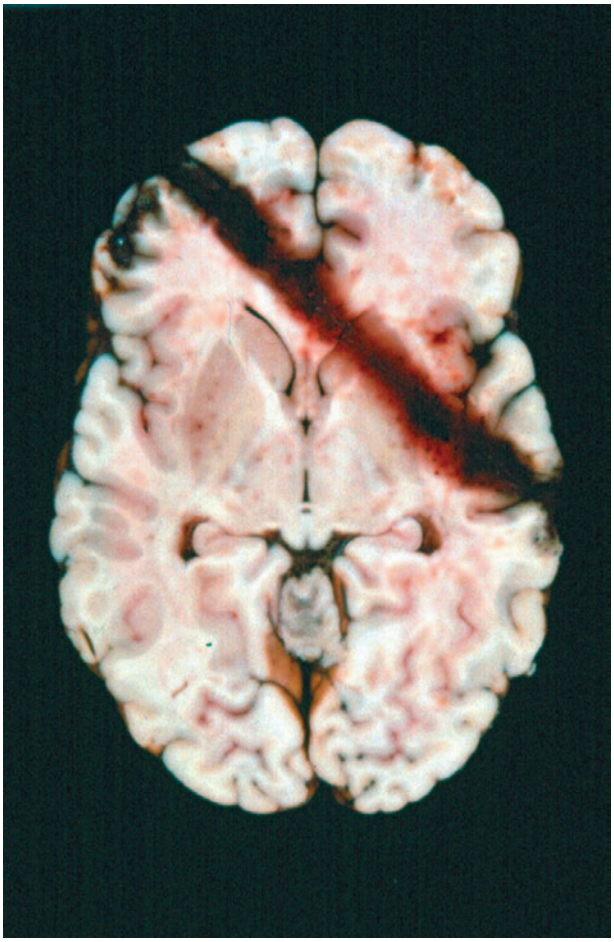


FIGURE 18.1 Oblique passage of 9 mm projectile through the brain. Entry via frontal pole. Note well defined hemorrhagic track and focal cerebral contusion at entry and exit sites.

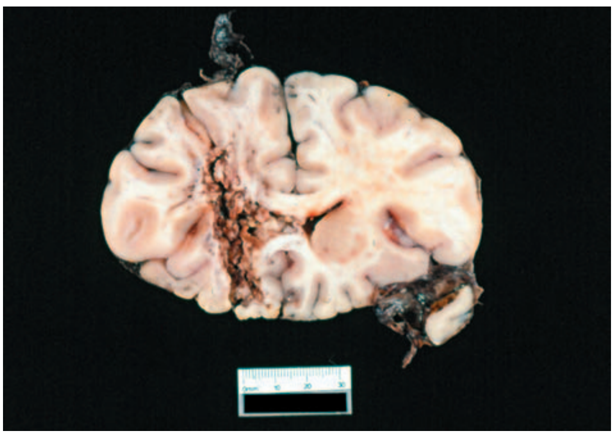


FIGURE 18.2 Near vertical passage of .22 cal projectile. Intraoral discharge. The track here is well defined but quite ragged and irregular in the region of the basal ganglia.

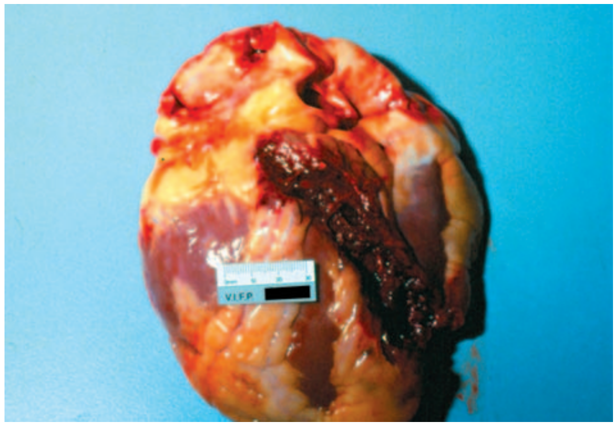


FIGURE 18.3 Tangential grazing shot to the heart. 9 mm projectile. Note ragged defect through the left ventricle. Death resulted from massive hemopericardium and hemothorax.

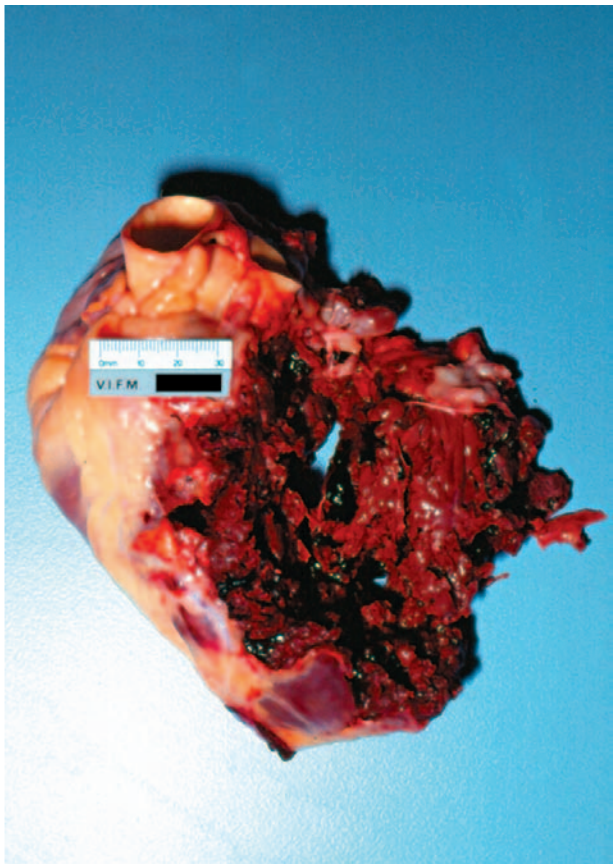


FIGURE 18.4 Massive disruption of the heart after hard contact discharge to chest. 12 gauge shot gun. Suicide.

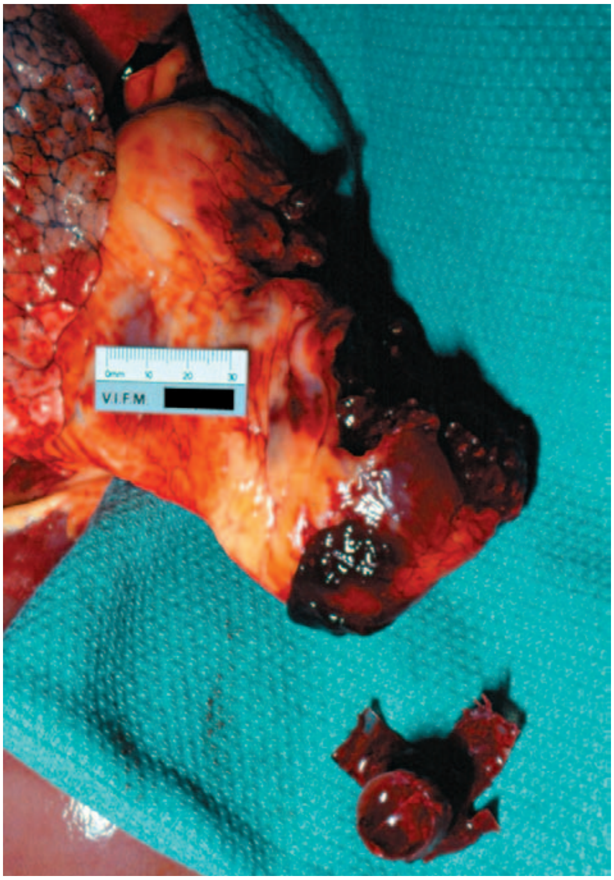


FIGURE 18.5 Massive damage to heart with loss of much of the left ventricle and entire left atrium. 12 gauge shot gun discharge to chest. Suicide. Note deformed plastic piston.

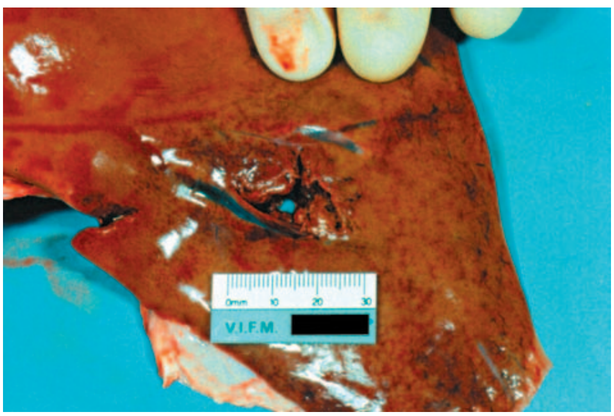


FIGURE 18.6 .22 cal discharge to abdomen resulting in a well defined track through the liver. Note exit point on posterior aspect with a zone of focal "beveling."

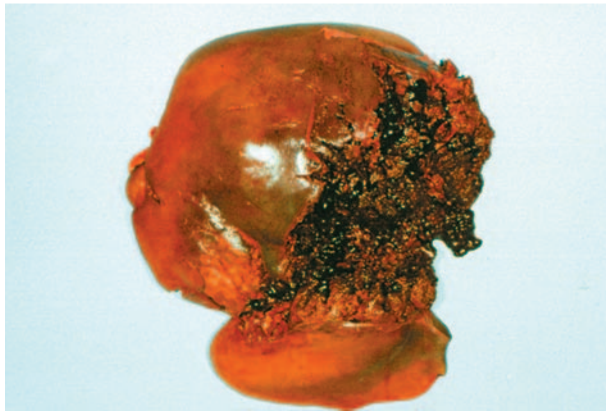


FIGURE 18.7 Massive hepatic disruption after hard contact range discharge to the abdomen. Suicide. .303 military rifle.

FIGURE 18.8 Complete transection of the aorta. Note ragged irregular lacerations at line of separation in tandem with shearing vertically oriented lacerations. .303 military rifle.

19 The Mimics of Gunshot Injury—Injuries in Life and Postmortem Artefacts

The forensic pathologist is often confronted by patterned trauma and artefacts that very closely resemble that of gunshot injury. This scenario may present at a crime scene or later in the postmortem room. Often, the astute mortuary technician will alert the pathologist to an area of injury on the body that raises the possibility of a gunshot. This is not uncommon in the "routine natural case" because the pathologist rarely sees the clothed body prior to autopsy.

Forensic pathology, by its very nature, demands a knowledge of the interpretation of injury and the mechanisms of trauma. It can be strongly argued that the interpretation of artefacts is most frequently the province of the pathologist. Indeed, the examination of a routine Haematoxylin and Eosin (H&E) tissue slide preparation is one of artefact interpretation and pattern recognition.

The standard forensic texts describe artefacts that mimic organic disease and trauma. Classic examples include lividity mimicing bruising, purging resembling hemorrhage, and resuscitation giving rise to injury that resembles exactly that of assault. It is the province of this chapter to deal with the mimics of gunshot injury. To this end, a classification is recommended.

I. Irregular objects travelling at speed (low or high velocity) — other than a conventional projectiles — metallic shrapnel, stones, glass, etc.
II. Regular objects penetrating the body at high speed — arrows, crossbow bolts, spears, nails, etc.
III. Regular objects penetrating the body at low speed — stabbings from skewers, spikes, screwdrivers, ice picks, etc.
IV. Static regular objects penetrating the body — falls onto protruding metal rods or spikes, etc.
V. Iatrogenic trauma (immediate medical intervention, resuscitation, and surgical procedures) — intravenous cannulas, intercostal and intraosseous catheters, burr holes, intracranial pressure monitors, drainage tubes, etc.
VI. Undertaker induced trauma — the introduction of a trochar and cannula during the embalming process.
VII. Artefacts arising from decomposition and postmortem animal feeding activity — fly infestation, larval deposition, migration of maggots, rodent predation, etc.
VIII. Special physical agents — direct heat, electrical and diathermy, caustic and corrosive agents.
IX. Miscellaneous — medical or surgical conditions such as ulcers or tumors.

The following examples are provided to illustrate the range of gunshot injury mimics.

Figures 19.1 to 19.6 — Shrapnel

A young boy died after being hit on the right forehead by a small metallic plug from the neck of a carbon dioxide cylinder (as used to produce soda water in soda siphons). The cylinder was thrown into a fire and exploded, expelling the plug at incredibly high speed. The entry wound consisted of a radiating complex of three well-defined lacerations with a subtle abrasion margin at its center point. The defect closely resembled a contact entry wound over a bony area or possibly an irregular exit wound. Deep to the laceration, a well-demarcated circular cranial full thickness defect with radiating fracture lines and internal/external beveling was identified. The metallic plug weighed 4 grain but produced a large complex skull fracture with cerebral trauma such as one might expect from the passage of a .38 caliber projectile, weighing in excess of 140 grain.

Figures 19.7 to 19.9 — Arrows

A man died after being pierced through the left posterior chest by an arrow with a field point tip. The arrow was fired by an amateur bowman in a back yard during a practice session. The arrow passed through a wooden fence before hitting the victim. A well demarcated linear defect recapitulates a distant range gunshot. Field point tips are designed to penetrate flesh and frequently exit the torso. These sturdy tips are not greatly impeded by solid objects such as fencing timber or thin metal. A large left hemothorax was demonstrated at autopsy.

Figure 19.10

A broad head type arrow tip is shown with an accompanying entry wound. The defect is stellate and resembles a gunshot exit wound.

Figures 19.11 to 19.13 — Fall onto a Static Object

This middle aged male construction worker fell from a first story level onto a protruding length of metallic reinforcing rod. After removal of the rod, a well-circumscribed circular defect with an abrasion collar is seen. This defect closely resembles a distant range 9 mm caliber entry wound.

Figures 19.14 and 19.15 — Stab Wounds

This elderly female's partner stabbed her multiple times with a barbecue fork. The injury consists of a cluster of well defined puncture wounds. Each shows a subtle abrasion rim. An injury pattern such as this may be confused with a distant range shotgun discharge. Implements such as skewers, spikes, and Phillips head screwdrivers will give a similar picture.

Figures 19.16 and 19.17 — Postmortem Predation and Decomposition

A circular defect with crenated edges is seen on the chest of this decomposed body. The artefact is the result of postmortem insect feeding activity, but may be confused with the "rat hole" defect of a close range shotgun discharge. A random pattern of small holes from maggot penetration may very closely resemble shotgun pellet scatter. An X-ray will quickly settle the issue. This man died from multiple stab wounds, a cut throat, and ligature strangulation.

Figures 19.18 and 19.19 — Iatrogenic Artefacts

This is an example of a defect caused by the insertion of an intercostal catheter. The defect may be confused with a distant range gunshot entry wound. The circular defect may occasionally show an abrasion rim. In the majority of cases, the catheter is secured by suture material and is frequently tethered to the skin by adhesive tape. If the tube is removed prior to autopsy, some doubt may be raised as to the underlying causation of the injury, especially in the bona fide gunshot victim.

Figures 19.20 and 19.21 — Undertaker Induced Defects

The embalming process is now a commonly performed procedure in the western world. Although far from ideal, it is not uncommon for the forensic pathologist to be asked to perform an autopsy on the embalmed body. Exhumation at a later date with the superimposed changes of decomposition may compound the confusion. The entry site of a trochar and cannula will leave a neat punched out defect that may recapitulate the distant range gunshot entry wound.

Figures 19.22 to 19.24 — Specialized Physical Agents (Electrical — Thermal Injury)

This middle aged female was electrocuted by her husband. A three pin electrical plug was applied to the mid chest. Effectively, this created a large circular diathermy wound. The circular defect with charred edges closely resembles a contact range 12 gauge shotgun wound. The radiating areas of erythema and vesicle formation have presumably been caused by the splashing action of superheated liquid body fat. Electrical "defense" injuries were noted on her right arm. The initial investigating officers suggested gunshot as a cause of death.

FIGURE 19.1 Clean edged triangular defect. Entry site of small metallic carbon dioxide cylinder plug. Note abrasion rim.

FIGURE 19.2 Carbon dioxide cylinder. These are extremely dangerous in the hands of young children and teenagers. The gas is stored at extreme pressure.

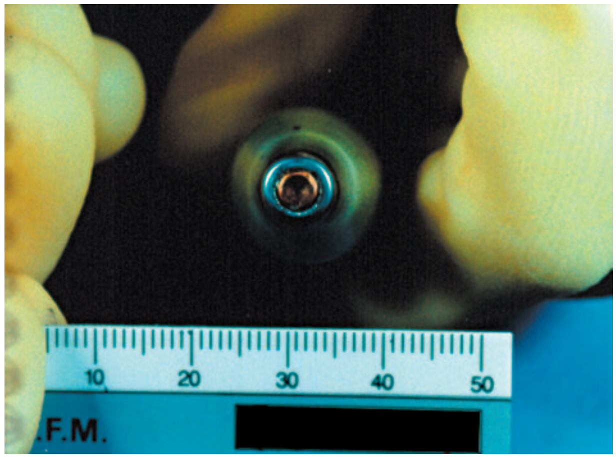


FIGURE 19.3 A close view of the small anodized metallic plug. The fragment weighed 4 grain yet produced injuries similar to a .38 cal. lead projectile.

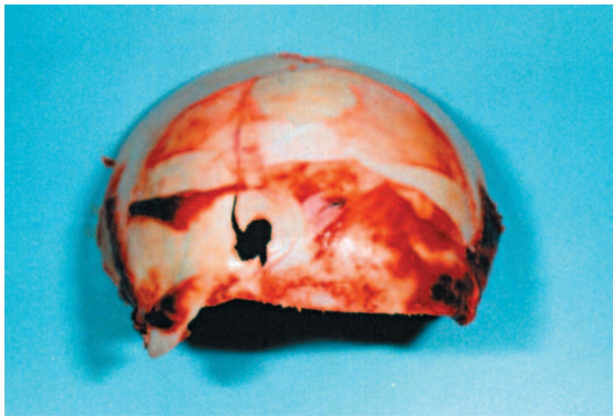


FIGURE 19.4 Skull low power. View of frontal cranial defect. Ovoid hole with radiating fracture lines. Extensive fracture lines were seen to involve the right parietal and occipital plates with widening of the sutures.

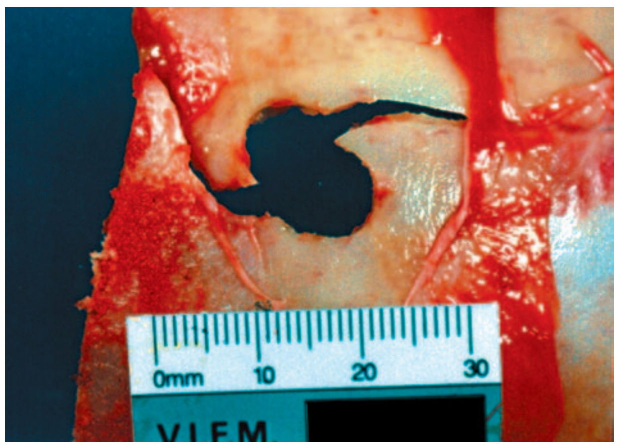


FIGURE 19.5 Close view of entry wound. Note clean edges with separation of fracture lines.

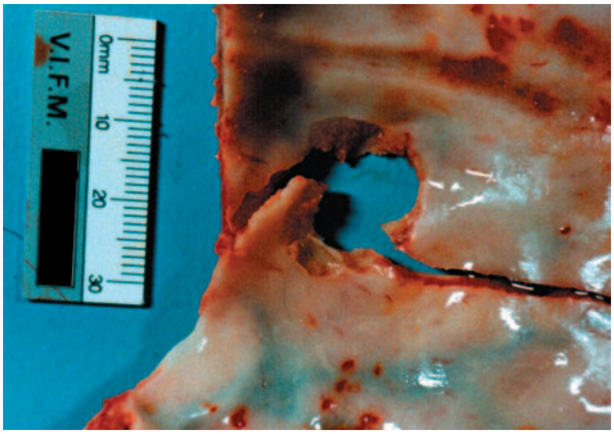


FIGURE 19.6 Beveling of inner table.

FIGURE 19.7 Nondescript entry wound from a field point tip arrow. Circular defect with abrasion rim, closely resembling a distant range gunshot wound.

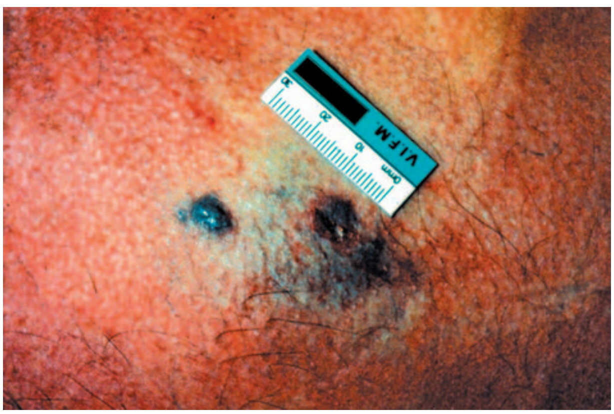


FIGURE 19.8 Close view of arrow entry wound. A small ovoid pigmented nevus is located to the left of the defect.

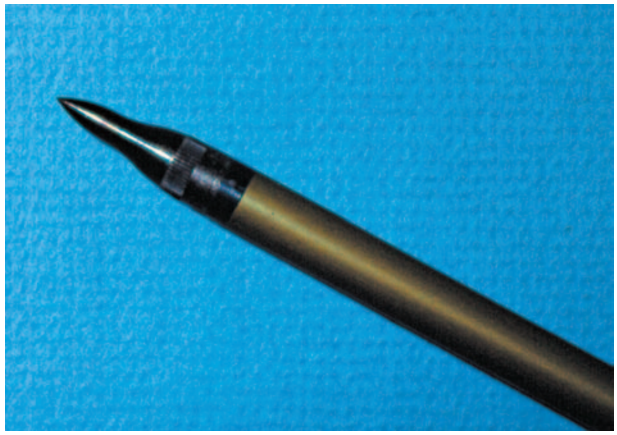


FIGURE 19.9 Field point arrow head. Arrow tip.

FIGURE 19.10 Broad head arrow tip (4-edge) and resultant entry wound. The defect resembles a bullet exit wound or possibly a contact wound onto a hard bony surface.

FIGURE 19.11 Impaling injury from a fall on to a protruding metal rod. Rod in situ.

FIGURE 19.12 Rod removed. Circular defect with abrasion rim closely resembling a distant range 9 mm entry wound. Drying of the wound edges may mimic blackening.

FIGURE 19.13 Metal rod removed from skull (lower) and similar intact rod.

FIGURE 19.14 Multiple stab wounds with barbecue fork with dual tines. A pattern of shotgun pellet scatter is produced.

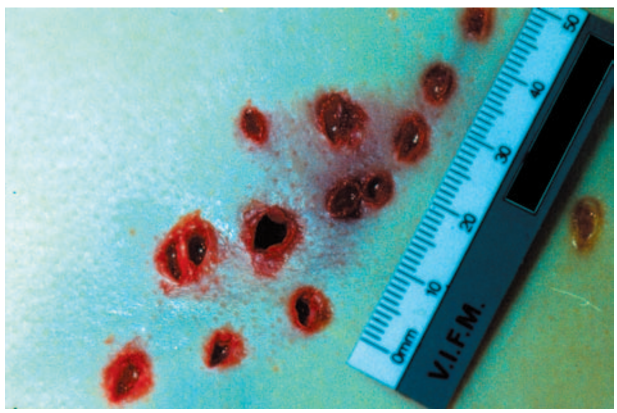


FIGURE 19.15 Close view of the above. Note small abrasion rims surrounding many of the circular defects.

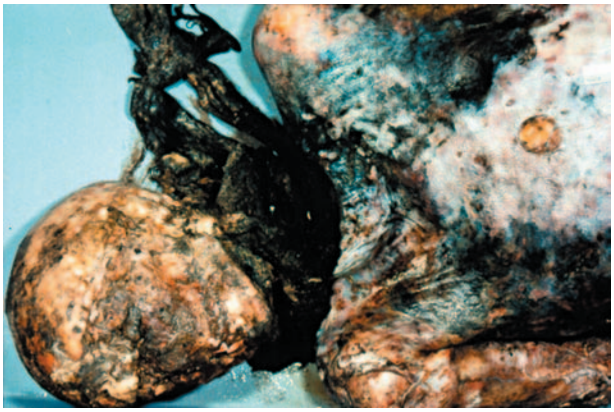


FIGURE 19.16 Decomposition postmortem fly and larval feeding activity. A circular defect resembling a "rat hole" shotgun injury is noted on the lower mid chest.

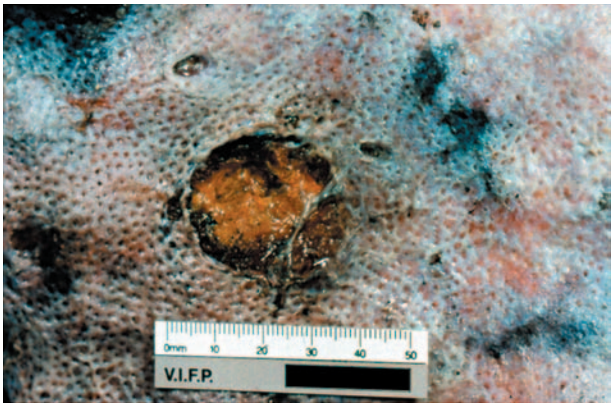


FIGURE 19.17 Close view. Note smaller peripheral round and circular defects.

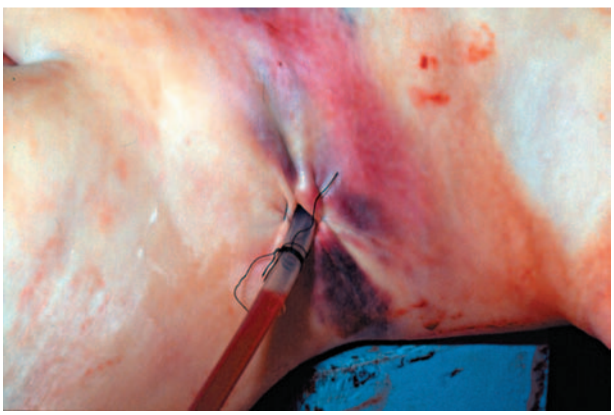


FIGURE 19.18 Iatrogenic defects. Intercostal drainage catheter tube in situ.

FIGURE 19.19 Intercostal catheter removed. The tube is generally sutured into position and secured with adhesive tape.

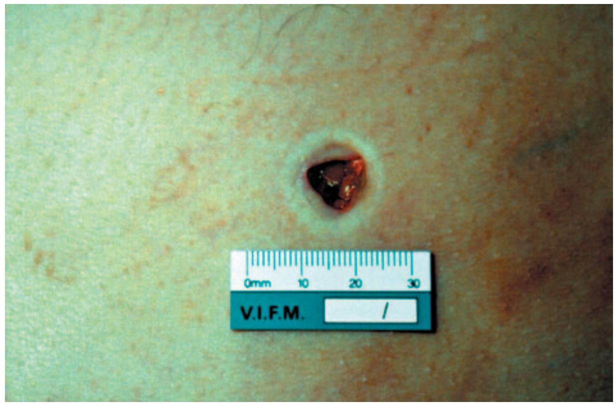


FIGURE 19.20 The effects of the undertaker's trochar and cannula. Note well defined blanched ringlike indentation with centrally located triangular full thickness defect. An abrasion rim may or may not be present.

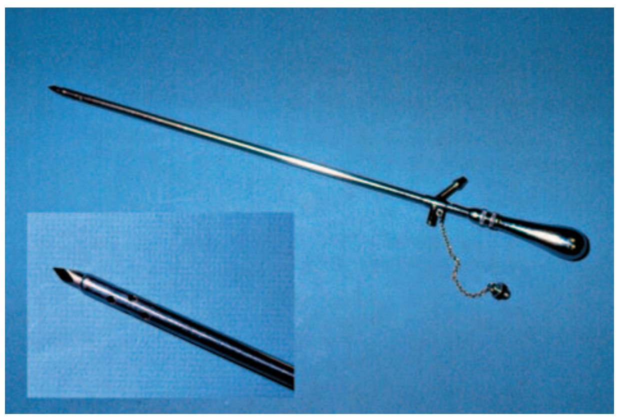


FIGURE 19.21 Trochar and cannula. Inset: note sharpened triangular tip.

FIGURE 19.22 Electrical thermal injury. Forceful application of a 3-pin plug to the anterior chest. This defect resembles a contact type 12 gauge shotgun entry wound.

FIGURE 19.23 Close view. Note charred edges and splashlike effect of super heated body fat.

FIGURE 19.24 The 3-pin plug. The extreme heat has melted the plastic center causing the pins to deviate from their normal vertical positions.

20 Exit Wounds

The most important consideration of an exit wound is that it be correctly assessed as such. Many cases are on record where an exit wound has been mistaken for an entry wound. This has a great impact on the final report, and if an incorrect assessment has been made, it may well have catastrophic repercussions at the time of inquest or trial. The forensic pathologist may literally be "blown out of the water" in court when it is ascertained that a mistake of this type has been made. All credibility can be lost in an instant.

The exit wound is created by the bullet emerging from the body. This statement would appear to be at first banal. We must realize that the exit wound is caused by the passage of the projectile only; there will be no sooting, searing, thermal effect, or tattooing/stippling. These qualities are also seen in the distant range entry wound.

In very rare cases, powder residues may be seen in the depths of an exit wound. If this is so, then residues should also be seen along the length of the bullet track. This phenomenon is usually restricted to heavy caliber rounds at close range. In the case of short passage, such as through a limb or head, this may be so, but almost never after a shot to the torso.

The forensic pathologist needs to consider several factors in the analysis of a case of gunshot trauma.

1. How many shots have been fired?
2. An accurate assessment of the range of shot.
3. The direction of fire.
4. The angle of fire.
5. An assessment of internal organ damage and survivability.

If the victim has a single entry wound, then the questions are simply answered.

In the case of multiple shots from different directions, entry wounds may be confused as exits, and vice versa.

Always consider the effect of overlying clothing. Any protected area may lose the classic features of contact and intermediate range shots. Overlying clothing may provide important clues, such as obvious eversion and partial extrusion of insulating material or fabric. All clothing items need to be examined closely and photographed.

Distant range shots can certainly be confused with exit wounds. In these cases, the use of radiology is highly recommended (most would deem it mandatory in any case!).

It is not uncommon to see a trail of lead particles in cases of high velocity discharge — the so called "lead snow storm." Larger particles gather towards the exit, as they have greater momentum.

In the case of intact projectiles, radiology may not resolve the problem, and it may be up to the pathologist to come to a conclusion based on internal anatomical findings.

The use of a probe may help to indicate the path of the projectile.

Exit wounds vary greatly in both size and shape. In an ideal world, all entry wounds would be neat and circular and all exit wounds would be irregular splitting lacerations. Sadly, this is often not the case. The exit is often a ragged irregular laceration with bruised edges, but it may also be a neat circular defect and its size may closely correspond to the diameter of the projectile.

Many exit wounds have everted edges with small radial splits. Some may demonstrate subtle abrasion rims although this is uncommon. Often, soft tissues project through the wound.

If the entry wound is not identified, a gross miscall may occur. The defect may be mistaken for a laceration secondary to nonspecific blunt trauma.

Wounds may have crushed or coarsely abraded edges or may have a "star burst" appearance as may be seen in hard contact shots to skin overlying tethered bone.

Exit wounds from rifled weapons (pistols, revolvers and small caliber rifles) tend to be small if fired from a distance. Higher caliber weapons are prone to shatter bone and cartilage, and in doing so, set into motion so called secondary projectiles. These fragments achieve velocities close to that of the primary projectile. The exit wound may become complex with multiple irregular discreet and often conjoined defects.

Jacketed projectiles may become dissociated in situ. The lead core may separate and/or fragment and the jacket may occasionally exit also.

Exit wounds after discharge of smooth bore weapons are quite variable in appearance.

At its most extreme, gross catastrophic disruption may be seen. This is especially so in shots in close proximity to the head.

Generally, shotgun pellets do not exit the body. Larger pellet sizes such as 00/SG may well do so if the shot is fired at close range. The SG pellets may be considered as nine (9) independent bullets and behave accordingly.

Solid slugs such as the Foster, Sabot, and Brenneke rounds readily exit, causing round to ovoid defects approximating the projectile diameter.

In all cases of sizeable solid projectiles, rigid internal structures such as bone and cartilage may readily deflect the passage of the projectile.

A bullet may enter the low neck in the transverse plane and exit from the mid abdomen, after striking the cervical spine. In cases such as this, the bullet frequently deforms and creates a larger more irregular exit.

Bullet deformation may occur in soft tissues, especially if the bullet is of hollow point or semijacketed configuration. The deformed projectile is highly likely to produce an irregular exit.

THE SHORED EXIT

This rather specialized exit injury pattern is not infrequently seen, especially in cases of multiple gunshot events. The shored exit is typified by an often circular or ovoid defect but in many cases may be frankly irregular. Surrounding the central defect, there is a broad irregular to ovoid zone of abrasion that typically has a "moist" appearance.

The mechanism of the shored exit is readily explained. As the skin protrudes externally, it impinges against a supporting surface, that is to say, it is “shored up.” The surface may be solid ground, a car seat, firm and close fitting clothing, or supporting undergarments.

If correctly assessed, much information may be gleaned about the position of the body at the instant of fire. The classic example is the *coup de grace* shot where the victim is lying either dead or dying on the ground. The entry may be to the back of the head or torso with the corresponding shored exit being located on the face, cheek, or chest.

In summary, exit wounds may appear as:

1. Neat circular defects
2. May show microsplitting of their edges
3. May be nondescript lacerations
4. May be complex lacerations with macerated edges
5. Do not show thermal effect, searing, blackening, or tattooing
6. Large untidy gaping wounds with maximal diameters greatly in excess of the projectile
7. May demonstrate a typical "shored" abrasion zone.

The following photographs illustrate the range of exit wounds seen in common forensic practice.

FIGURE 20.1 Exit wound — right temple. 22 cal. Suicide. This wound is typified by an elongated irregular laceration with everted edges.

FIGURE 20.2 Exit wound to vertex of scalp. Intraoral discharge. .22 cal. Suicide. The wound is nondescript and may readily be confused with nonspecific blunt trauma. Note angulated split at lower edge.

FIGURE 20.3 A very irregular and untidy lacerated exit wound. .22 cal. Suicide. Note radiating curvilinear laceration and macerated wound edges.

FIGURE 20.4 The occasional exit wound may be sutured if there is a survival period. .22 cal. Suicide.

FIGURE 20.5 Small irregular circular and splitting exit wound to the posterior neck. .38 Special. Suicide. Intraoral discharge.

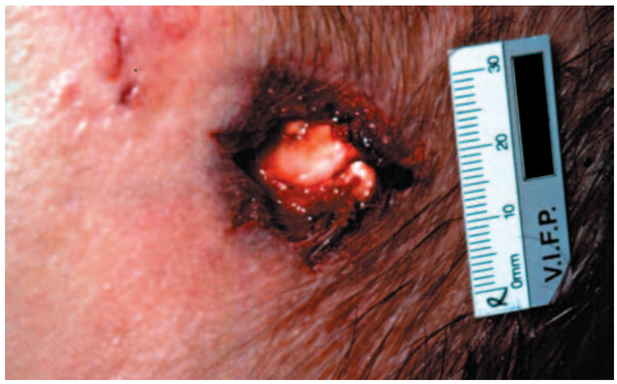


FIGURE 20.6 Large irregular burstlike exit wound to temple. .38 Special. Entry to right temple. Brain substance is on view.

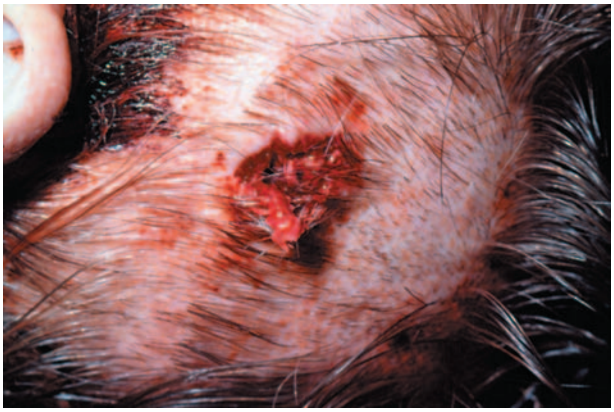


FIGURE 20.7 Irregular exit wound to temple. Soft tissue is everted and extruded. This wound has abraded edges and may be considered to be a shored exit.

FIGURE 20.8 "Star burst" like exit to temple. Radiating splitting lacerations are seen. This closely resembles a hard contact entry wound. 9 mm. Suicide.

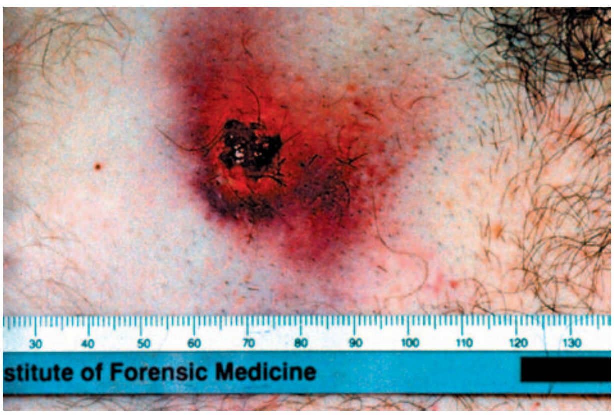


FIGURE 20.9 Irregular but predominantly circular exit wound. Note regional bruising. 9 mm. Homicide.

FIGURE 20.10 Massive explosive burstlike exit wound to the head. .30-06 Hunting rifle. Suicide. Note outward petal like displacement of calvarium and scalp. Note also the well demarcated muzzle imprint and entry defect beneath the chin.

FIGURE 20.11 Large ovoid defect to upper left back. .45-70 Hunting rifle. Suicide. The wound is approximately 20 mm in greatest dimension. Note microsplitting and small everted edges.

FIGURE 20.12 Multiple exits from a hard contact shotgun blast to the chest. 00/SG shot shell. Suicide. Eight of the nine pellets have exited. The ninth remains in the subcutis. Secondary projectiles may create a similar pattern.

FIGURE 20.13 A gunshot exit wound mimic. Exit wound from a nail gun discharge. The plate of the gun was placed beneath the chin. Note the resemblance to an earlier .22 caliber exit.

FIGURE 20.14 A true shored exit. The bullet entered the left parietooccipital scalp. The victim was in the face down position. Note elongated ovoid defect with wide abraded margins. .38 Special. Homicide.

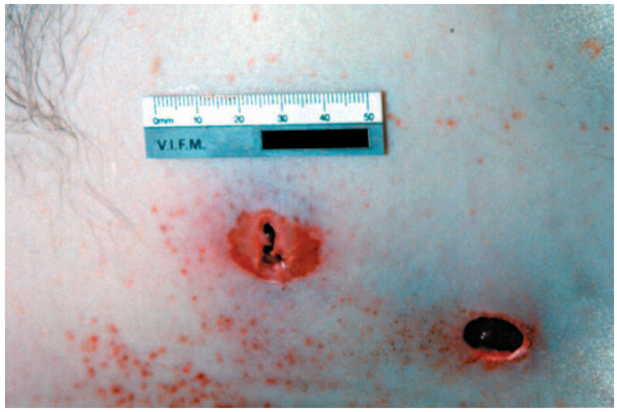


FIGURE 20.15 A classic example of a shored exit (top). Note "moist" appearance of the abrasion zone and an irregular exit defect with ragged everted margins. The lower wound is of intermediate range. Unburnt powder particles may be seen on close inspection. .38 Special. Homicide.

FIGURE 20.16 A further example of a shored exit. Note exaggerated eccentric and ovoid zone of abrasion. In addition, areas of punctate abrasion are noted in the immediate area indicative of impact of the skin edge against a resisting surface.

Part C

Technique

21 Management of the Gunshot Wound Surgical Resection Specimen

In the vast number of cases, the entry (and possible exit) wound will be examined and, hopefully, faithfully documented by the attending casualty surgeon. Experience has shown that often, the case notes are far from accurate in their description. The gunshot injury may be described in a nondescript fashion, notated simply as "bullet hole." Entry and exit may be confused, with serious implications later. Frequently, the "pathological range of fire" is not estimated or is simply wrong. On rare occasions, the forensic pathologist may be requested to examine an excised surgical specimen from the survivor victim of a gunshot injury. The police agencies will almost certainly expect the questions of range, angulation, and possibly caliber to be addressed.

The excised specimen may be received in the fresh state, but frequently is seen as a formalin fixed specimen, often several days later, by the anatomical pathologist. The surgical pathologist may decide to refer the case, quite appropriately, to the forensic pathologist. The specimen should, on receipt, be photographed with and without scale and be allowed to adequately fix prior to section. The forensic pathologist should examine all X-rays performed in hospital pertaining to the gunshot area. There may be a case for radiological examination of the specimen to be performed in certain cases.

An accurate description should be made with due regard to the overall dimensions of the specimen, as would be performed in any skin biopsy. In the interest of detail, accurate description must be made of the presence of an abrasion collar, searing of the epidermis, blackening, soot deposition, tattooing, heat effect on adjacent hair shafts, and of course, the direction and dimension of the penetrating defect.

A blunt probe (size appropriate to the defect) should be gently passed through the track, and serial sections then cut through the width of the specimen. An attempt to pass a larger probe may theoretically cause displacement of indwelling carbon pigment and unburnt powder granules.

A disposable microtome knife blade is preferred to the standard scalpel to provide precise serial sections.

Routine Hematoxylin/Eosin sections are requested; deeper levels may be required after the initial slides are examined.

Standard color photomicrography is advised to be performed as this will provide excellent and functional evidence in a court of law.

The use of polarization is strongly recommended, especially to demonstrate unburnt powder granules. Embedded foreign bodies (clothing fabric, etc) may also be highlighted in this fashion.

CASE WORK: "RUSSIAN ROULETTE"

Figures 21.1, 21.2, and 21.3 adequately resolve the problem of range and angle of fire in a case of "Russian Roulette." A 35-year-old man, while under the influence of alcohol, was persuaded into taking part in the lethal game of Russian Roulette. A .22 caliber revolver was the weapon of choice. The victim survived and charges were laid against the other party. It was alleged that the victim may have deliberately angled the muzzle so as not to receive a life-threatening shot.

Figure 21.1. The range is one of classic contact type — a muzzle imprint is not represented. Note that the regional hair of the scalp has been shaved in preparation for emergency neurosurgery.

Figure 21.2. The bullet has passed from left to right in the transverse plane. An oval window was excised from the exit site. The fragments are reassembled and a classic circular defect with external beveling is revealed. Note that there is no obvious angulation or ovoid configuration, a finding fully in keeping with the muzzle being placed perpendicular to the temple.

Figure 21.3. The histology confirms the range of fire. Burnt powder is seen in the depths of the bullet track. Vital reaction to injury may also give a clue to survival time in the "out of hospital" death. The presence of haemosiderin, fibroblasts, macrophages and giant cells may, in some circumstances, be useful in "time of event determination."

CASE WORK: "KNEE CAPPING"

Figure 21.4 shows the presence of particles of burnt propellant adjacent to the popliteal artery. Unburnt powder (Figure 21.5) is shown and highlighted by the use of polarized light microscopy (Figure 21.6). The presence of both burnt and unburnt propellant in the depths of the wound confirm this as being a contact shot. As is usually the case, the entry and exit wounds were not photographed and the surgical notes did not address the forensic issues. Photographs were not taken prior to the surgical repair to the knee. The slides were referred to a specialist forensic pathologist from the surgical pathology department as an afterthought.

The above cases highlight the need for accurate record keeping and descriptive skills to be developed by our surgical and medical colleagues.

FIGURE 21.1 The skin excision as received showing a well demarcated circumferential zone of blackening and a central circular defect. The adjacent hair shafts have been shaved prior to neurosurgery.

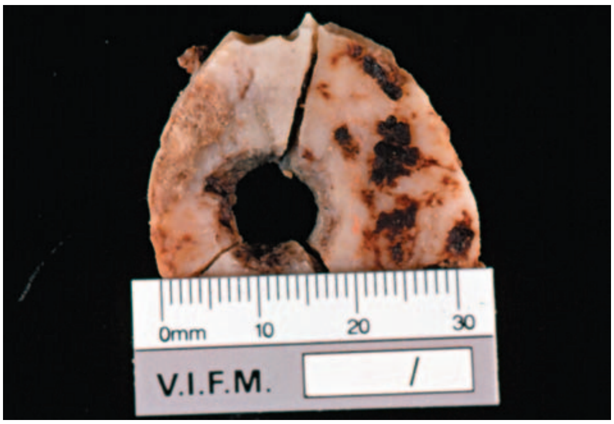


FIGURE 21.2 Reassembly of the bone excised from the "exit" site. The defect is circular, shows bone fragments, external beveling, and indicates a perpendicular shot.

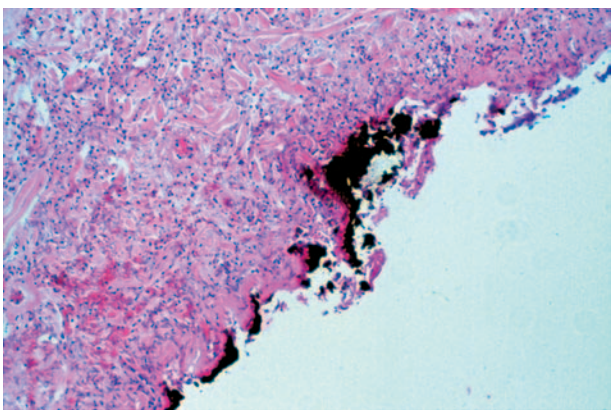


FIGURE 21.3 A routine H.E. section at medium power showing dense blackening along the bullet track. A polymorph response indicates a survival period.

The forensic pathologist can be instrumental in the development of these skills by providing workshops and in-house tutorials to the casualty staff as the part of ongoing education commitments.

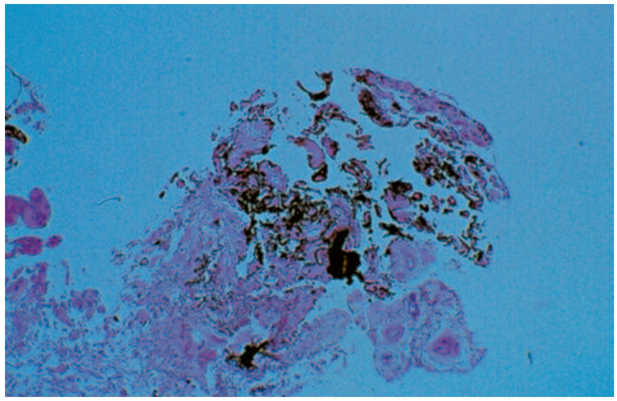


FIGURE 21.4 Burnt powder fragments in soft tissue adjacent to popliteal artery. Low power. H.E.

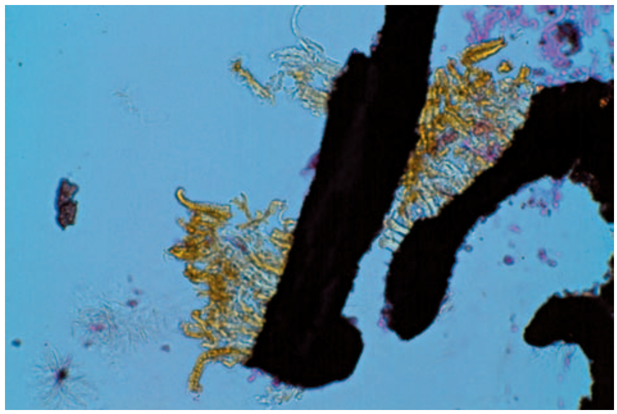


FIGURE 21.5 Unburnt powder fragments as seen in plain light microscopy.

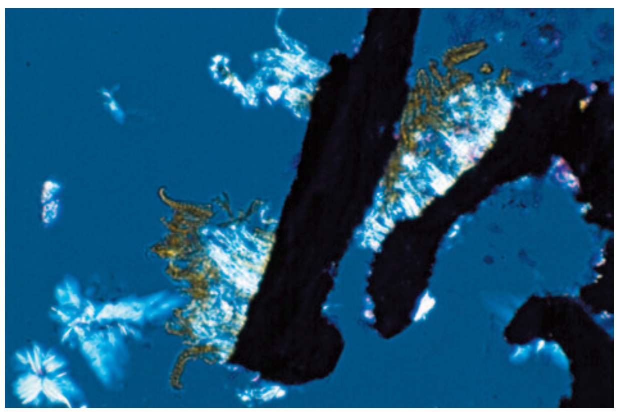


FIGURE 21.6 Polarized light may enhance unburnt propellant.

A Recommended Technique for Cutting and Placement of Resected Gunshot Entry Specimens

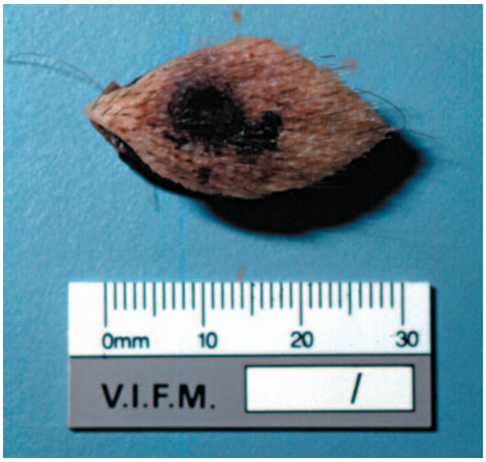


FIGURE 21.7A The formalin fixed resection. A full macroscopic description has been made.

FIGURE 21.7B A blunt probe of suitable thickness is gently passed through the track.

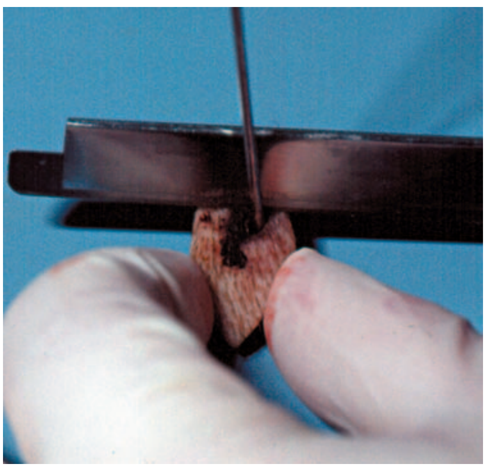


FIGURE 21.7C A Microtome blade is recommended to ensure a clean parallel slice.

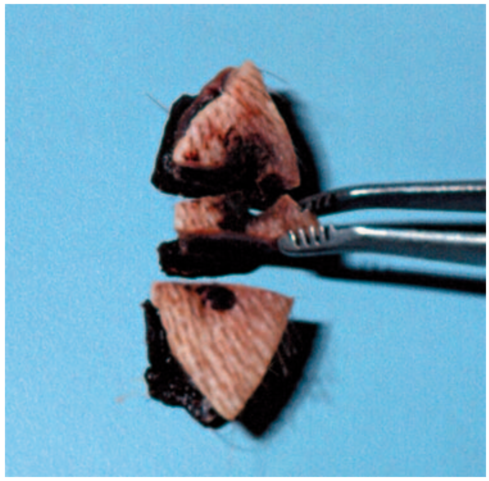


FIGURE 21.7D A suitable slice is selected for histological examination.

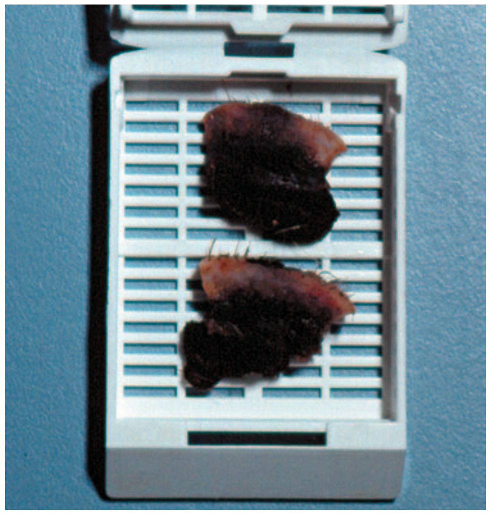


FIGURE 21.7E The section(s) is placed in a cassette for processing.

22 Gunshot Residue Sampling and the Ballistics Expert

Extensive laboratory investigations are performed on samples and evidential materials taken prior to and after the gunshot autopsy. This exacting work is undertaken by highly trained and experienced personnel and is beyond the expertise of the forensic pathologist. The pathologist, however, should be familiar with the rudimentary principles so as not to compromise results that may have vital importance at a later date.

It is beyond the scope of this book to detail the exacting work performed by the firearms section of a forensic investigation laboratory and therefore only essential and basic information will be described.

GUNSHOT RESIDUE (GSR)

At the instant of weapon discharge, a large volume of hot gas, smoke and finely divided particulate matter exit the barrel along with the projectile(s). The firing hand will receive a certain amount of GSR. It is the location of GSR on the hand, relative to anatomical landmarks, that will decide whether the gun has been fired by that person or merely handled in a nondescript fashion.

Gas and fine particulate matter will escape from spaces between the back of the cylinder and the frame in the case of a revolver and from the breech and opened slide in the case of a semiautomatic pistol. Bolt action rifles and shotguns tend to expel less material onto the firing hand, as the closed chamber and breech are of a tighter fit. GSR may, however still be detected.

GSR may be deposited on and over the thumb and index finger, with varying amounts on the lateral one-third of the palm and "anatomical snuffbox" areas. GSR sampling is therefore a selective process. The areas indicated previously need to be sampled directly and so labelled.

Residue found on the palm of the hand may simply indicate "passive" handling of the firearm.

Residues need to be protected from the action of friction against clothing and washing or wiping by the mortuary technician. A useful technique, if GSR sampling is to be delayed, is to place a plain brown paper bag over the hand and wrist. The bag should be secured at the wrist by adhesive tape. Plastic bags are to be avoided at all costs. Condensation tends to accumulate rather quickly and may cause GSR to smudge and redistribute.

Who should perform GSR sampling? In some jurisdictions, the mortuary technicians may perform this task. In others, it will be a specifically trained representative of a crime lab. In problematic cases and in those of obvious homicide, the task is better performed by highly experienced personnel. Qualifications and experience speak loudly in a court of law, and in addition, detailed questions relating to the actual procedure may also be asked by defense council.

GSR may be sampled by the application of adhesives to the skin or better still, by purpose built stainless steel studs (that resemble washers from a water tap) with adhesive edges. Specific areas are swabbed, labelled, and transferred with a sound chain of custody form.

Modern technology has largely replaced the time-honored application of chemical testing, such as the Sodium Rhodizonate method, which detected the presence of lead primers. Scanning electron microscopy (SEM) is now the preferred method. The advantage is one of detection of minute quantities of GSR, and in addition, to be able to classify certain elemental combinations.

Although large volumes of gas escape at the instant of discharge, it is the residues from the primer explosion that are important. Elemental residues such as antimony, lead, and barium are readily identified at high magnification. GSR particles are seen as round to ovoid bodies that may demonstrate a somewhat mottled and pockmarked surface. With appropriate imaging modalities, these minute particles may be discriminated from amorphous background debris. Electron emissions from these particles can then be translated as peaks on a print out graph. The combination of elemental residues is, in essence, more important than their mere presence.

Although the hardware is expensive, these modern methods provide useful and exacting data and images that provide convincing evidence in a court of law.

Once GSR has been sampled, a specific label indicating this fact should be applied to the wrist, so all staff are now aware that the process has been completed.

It is good practice for the forensic pathologist to attend at the time of GSR sampling. There is always the possibility that other trace evidential material may be present in the palm of the hand or grasped by the fingers that may otherwise be lost or redistributed prior to formal autopsy.

THE ROLE OF THE FIREARMS EXAMINER AND BALLISTICS EXPERT

The firearms examiner or ballistics expert is a vital and integral member of the team of examiners in the investigation of gunshot fatality. He may be a senior police officer with specific training, or a university or college graduate in the forensic sciences. His role can be categorized as one of:

1. firearms examination
2. cartridge and projectile examination
3. test firing and range determination

All firearms seized during case investigation must be submitted to the appropriate personnel, rather than being merely photographed and stored as an exhibit that can be produced in court at a later time.

Firearm integrity and safety are quickly ascertained. The classification, model, and manufacturer are recorded, as is the serial number. Considerations regarding trigger pressure and the identification of mechanical faults are tested and duly recorded. The depths of the bore of the gun should be examined for biological matter.

In some cases, finely divided human tissue fragments and fine blood spatter may be detected — a phenomenon known as "blow back." Sampling of such material is of obvious importance in the conduct of a successful prosecution.

The modern ballistics laboratory area will have a facility for safe test firing over varying distance, spent projectile retrieval, bullet and cartridge case comparison and determination of rifling marks and their configuration. In many centers, projectile retrieval is achieved by firing the cartridge into a purpose filled water tank or into finely divided cardboard or paper. In either case, it is critical that deformation of the bullet is minimized.

A comprehensive gun and ammunition collection is also essential. A questioned weapon can readily be loaded with comparable ammunition and test fired. The characteristics of the resultant rifling pattern on the lead projectile or jacketing can be directly compared with an extracted bullet under the comparison microscope. The spent cartridge case can also be examined for the telltale marks made by the firing pin or hammer and also by the ejector mechanism.

Put simply, the comparison microscope is a precision optical instrument comprising two microscopes set side by side, so individual and overlapping images can be viewed through the one eyepiece.

The effects of the lands and grooves of the barrel (rifling marks) and of the firing pin and ejector mechanism (tool marks) can be viewed in the one field once the projectile or cartridges have been clamped in position and independently rotated. The effects of rifling or ejectors may be as individual as fingerprints. Irregularities within the barrel or at the muzzle may be represented on the projectile, as may be irregular projections or metallic deficiencies on the ejector mechanism.

Photography of the final image can also be performed — yet another source of evidential material that may be used in court.

Perhaps the one test that the forensic pathologist can readily relate to is range of fire determination by stepped test firing. The questioned weapon (or one that is comparable) is loaded with ammunition of a type used in the shooting. In the case of shotgun discharge, the pellet size must be the same as that identified at autopsy.

The gun, after safety testing, is mounted on a remote firing platform and repeatedly fired at test cards placed at measured and advanced distances from the muzzle. The resultant pattern of projectile, soot and pellet scatter can then be matched to the injuries seen at autopsy with a reasonable degree of precision. This technique lends itself well to the testing of smooth bore weapons (shotguns). The degree of pellet scatter relates to barrel length, degree of choke, and propellant load.

Many forensic pathologists have been faced with a scenario of the gun "going off accidentally while being cleaned" when the victim is said to have been standing very near to or indeed over the muzzle. Realistically, this scenario should produce a tight central pellet aggregate with few, if any, peripheral fliers. The postmortem finding of pellet spread beyond the "rat hole" stage seriously questions the proposed scenario if a distance of a few feet between muzzle and victim is suggested by the accused. A distinction between a muzzle distance of two to three feet may well be possible after test firing of the questioned gun with comparable ammunition.

The experienced firearms examiner will also possess knowledge of the components of cartridges, weights of projectiles, projectile flight velocities, and propellant types as well as weapon design and construction. In addition, the firearms examiner will be fully competent in the breakdown and reassembly of the components of many firearms and will therefore be able to attest to the presence or absence of faults of the gun in question.

The firearms examiner frequently attends the forensic autopsy to take contemporaneous notes of the injury patterns and to escort the retrieved projectiles back to the ballistics laboratory. A detailed report is ultimately produced by the firearms examiner. This report will be used as evidence in court.

The combined efforts of the forensic pathologist, GSR technician, electron microscopist and ballistics expert are the epitome of team work.

The following photographs detail the GSR sampling process and the exacting work of the firearms expert.

FIGURE 22.1 A high speed flash photograph of a revolver at the instant of discharge. Large volumes of gas are emitted from the muzzle and also a certain amount escapes from the cylinder gap. The residues from the primer are sought in GSR sampling. (Photograph courtesy of A/Prof Gale E. Spring-Royal Melbourne Institute of Technology University).

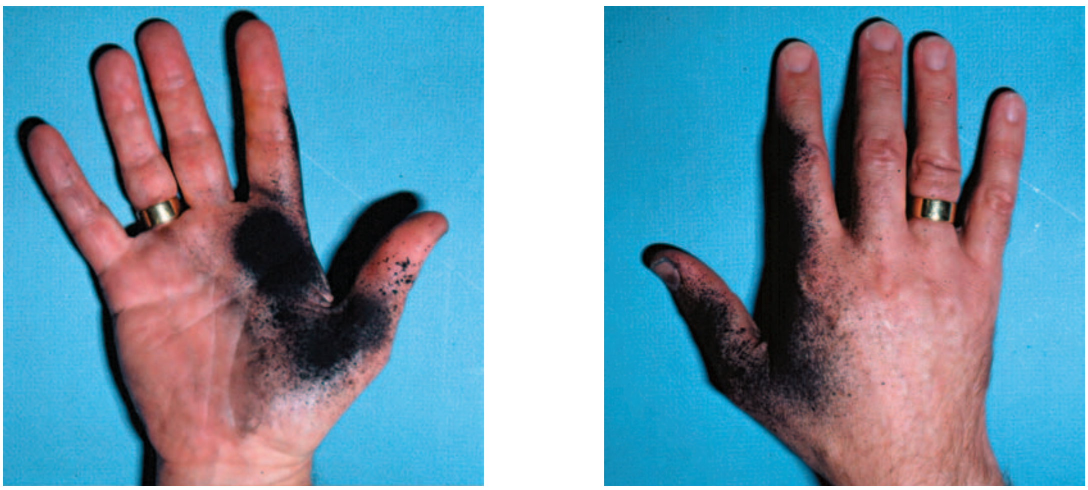


FIGURE 22.2 The classic distribution of GSR on the firing hand. Finely divided spray on graphite has been used to highlight the areas of GSR sampling and distribution.

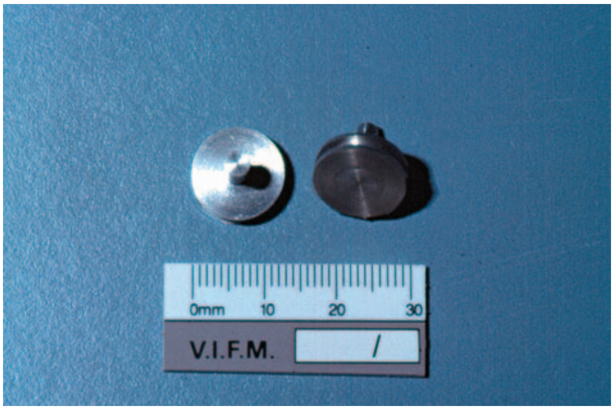


FIGURE 22.3 Small stainless steel studs with adhesive surfaces are used to pick up the fine GSR from the skin of the proposed firing hand.

FIGURE 22.6 The scanning electron microscope has revolutionized the detection of GSR.

FIGURE 22.4 The studs are gently and repeatedly applied to the skin. Each stud is then labelled as to site and later transferred to the laboratory under chain of custody.

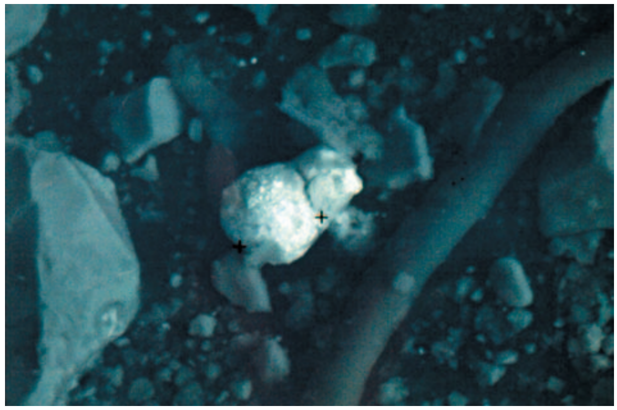


FIGURE 22.7 A SEM generated image of a primer residue fragment × 1770. The GSR particle measures 120 × 96 μm. The elemental composition can be determined from signals generated by electron emission.

FIGURE 22.5 The wrist is then tagged with an appropriate GSR sampled label. All staff are now aware that the sampling has in fact been taken and the autopsy can now begin.

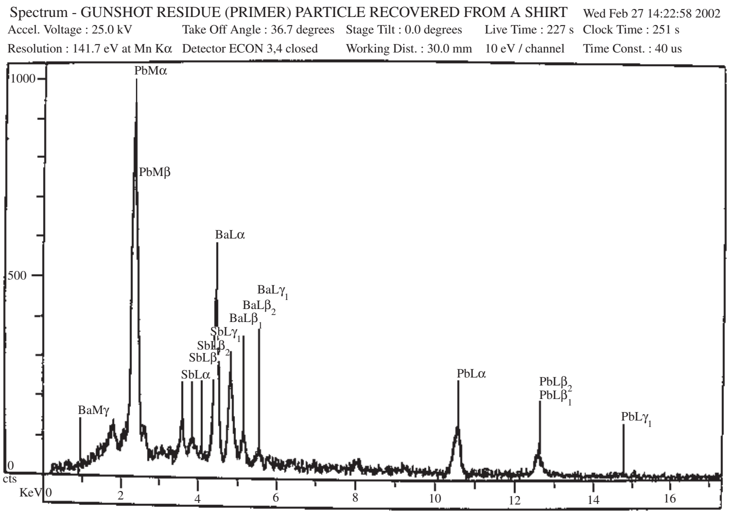


FIGURE 22.8 The data is recorded as signal peaks on a printout. The peaks indicate elemental composition. Antimony, barium, and lead are readily identified. The combinations of these elemental constituents are as important as their detection.

FIGURE 22.9 A firearm examiner using the comparison microscope. The questioned and comparison projectile or cartridge cases can be individually mounted, rotated, and viewed through the eyepiece in a split image mode.

FIGURE 22.10 A split image view of a questioned and comparison cartridge baseplate. Careful attention is paid to the pattern imparted by the firing pin and ejector mechanism.

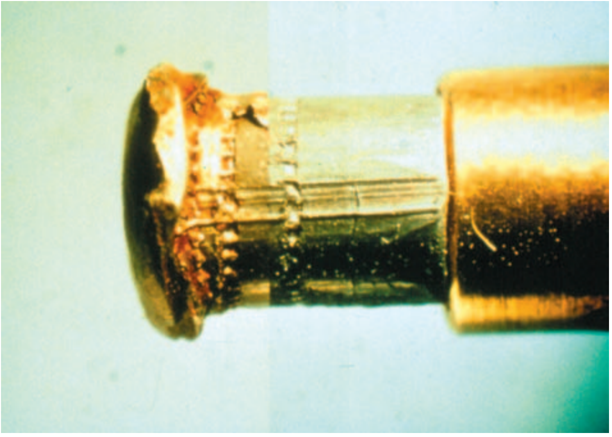


FIGURE 22.11 The typical rifling marks on a projectile caused by the lands and grooves of the barrel of the gun.

FIGURE 22.12 A modern test fire range with mobile overhead target and remote firing mechanism.

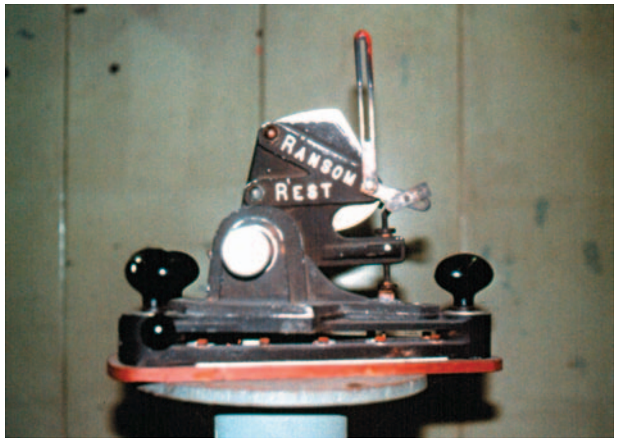


FIGURE 22.13 A close view of the remote firing device which will accommodate both revolver and semiautomatic pistol. A similar device can be used for the test firing of long arms.

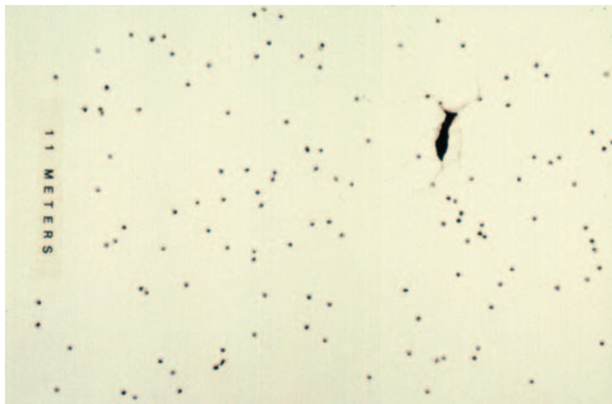


FIGURE 22.14 A typical test fire card. In this case, a 12 gauge shotgun has been discharged at a distance of 11 meters from muzzle to target.

23 Radiology

In 1885, Dr Wilhelm Conrad Roentgen, Professor of Physics of the University of Wurzburg, chanced upon the discovery of x-rays. This tremendous discovery, which has literally changed the practice of medicine and surgery, came about after a series of dedicated experiments investigating the origin of spontaneous fluorescence of a barium platinocyanide coated screen that was in close proximity to an energised cathode ray tube. After 50 days of unrelenting research, Dr Roentgen was able to demonstrate that these newly discovered rays (now called X-rays) had the ability to penetrate material such as paper, wood, fabric and a number of metals.

The ultimate experiment that guaranteed the medical application of X-rays was the successful visualization of the bones of his wife's hand. The outline of the ring on her fourth digit was also clearly delineated. On New Year's Day 1886, Dr Roentgen's discovery was disseminated to the world. The medical applications were immediately grasped by the practitioners of the day.

It can be strongly argued that the application of radiology, as this new science had come to be known, constitutes one of the greatest advancements in the pursuit of forensic pathology and certainly in the subspeciality of wound or terminal ballistics. The application of radiological technique to the needs of forensic pathology is extensive:

1. To assist in the identity of the unknown individual
    - age
    - height
    - gender
    - identification of old fractures and orthopaedic inserts
    - congenital defects
    - frontal sinus patterns
    - dental examinations
    - determination of ossification centers

These latter parameters are especially useful if ante mortem radiographs are available for comparison.

2. The examination of the knife attack victim
    - presence of detached knife tip
    - identification of bony injury
    - presence of haemo/pneumothorax
    - presence of air in cardiac chambers and great vessels

3. Investigation of child abuse
    - skeletal survey
    - presence of old or recent fracture
    - presence of congenital bone disease that may predispose to fracture

4. Investigation of hangings and strangulations
    - hyoid, thyroid, and laryngeal fractures
    - cervical spine/odontoid peg fractures

5. Investigation of cases of gross thermal injury, decomposition, and apparent drowning
    - identification purposes
    - disclose unexpected foul play (i.e., the presence of projectiles)

6. Investigation of SCUBA related deaths
    - presence of pneumothoraces
    - demonstration of gas embolus

7. Contrast studies
    - demonstration of vertebral artery dissection

8. Obscure poisoning and toxicity
    - presence of lead lines
    - presence of Thallium

The application of radiology to the investigation of gunshot injury is invaluable. Many immediate questions may be answered after the taking of standard anteroposterior (AP) and lateral films at the time of admission of the body to the mortuary.

1. Are projectiles actually present within the body? Exclude the mimics of gunshot injury.
2. How many projectiles are present?
3. What are their anatomical locations, particularly in reference to the apparent entry wounds?
4. Can the direction of fire be predetermined prior to internal examination?
5. Assessment of the nature of the projectile (smooth bore vs. rifled weapon).
6. Estimation of caliber — are several calibers represented?
7. Presence of separated jacketing — demonstration of projectile fragmentation.

8. Demonstration of the presence of a classic "lead snow storm" strongly indicating a high velocity projectile.
9. Demonstration of bony injury that would not ordinarily be shown on routine internal examination.
10. To indicate the presence of the Black Talon projectile. The sharp barbed points of this projectile may constitute a safety hazard for the examining pathologist.
11. To provide a useful form of data collection that can be used later as evidence in a court of law.

The modern forensic pathology facility has a radiology department. Ideally, the department should have a standard hospital X-ray machine mounted on a gantry for precise positioning.

Processing of this film can either be "wet" or "dry." Modern dry developing machines can produce plates within several minutes for rapid initial assessment prior to autopsy.

All X-rays should be taken prior to stripping the body of clothing. It is surprising how often projectiles may become entrapped in layers of clothing in cases of multiple gun shot.

Great care must be taken to prevent the loss of projectiles as these are vital as evidential material.

The *image intensifier* is also of great use. This instrument allows "real time" examination of the body. The image is projected onto a closed circuit television monitor; a "hard copy" can be produced by the addition of an online printer. These images are also of great use as material evidence in a court of law. A body can be readily scanned in less than ten minutes.

PITFALLS

In spite of the great boon to ballistics investigation, there are certain pitfalls that all forensic pathologists must be aware of. As the X-ray beam extends from the tube to the plate or detector, there is an appreciable degree of apparent magnification. Objects (projectiles) closest to the plate will appear at a size very close to reality, while projectiles nearest the emitter will appear somewhat larger. The problem here is immediately clear. Caliber estimation is frequently erroneous on first inspection of the developed X-ray plate. Projectiles of .32 and .38 caliber may appear to be of the same size depending on their location within the body. Projectiles of .22 caliber may be confused with .32.

Note that .38, .357, and 9 mm projectiles are essentially the same on direct examination in any case. These caliber projectiles may be artefactually enlarged and resemble a .44 caliber projectile given sufficient distance from the X-ray plate. It is wise not to give an opinion before the projectile is actually "in hand."

The use of a probe is advantageous in locating the projectile when using the image intensifier. With practice, bullet location can be achieved quickly once the body cavities are opened.

The problem of magnification equally applies to lead shot discharged from smooth bore weapons. Small diameter shot will appear slightly larger on the X-ray plate. This is not necessarily a problem, as ultimately a representative sample of shot should always be collected and submitted to the ballistics expert. Larger pellets such as buckshot often deform and can readily resemble a deformed solid projectile fired from a hand gun or rifle. A distant range shot from a cartridge containing 0 or 00 buckshot may strongly resemble on X-ray that of multiple shots from a hand gun.

In most cases, however, careful extraction and examination of these projectiles (all should be sought) will resolve the problem. The question of *range of fire* from smooth bore weapons has been previously considered under the chapter entitled "Shot Gun Injury Patterns." The range of fire (that is, the distance from muzzle to target) can *never* be ascertained from radiological images. As previously emphasized, pellets are immediately dispersed within the body after penetrating skin, bone, and muscle. A contact range discharge (estimated by examination of the skin defects) will frequently show extensive pellet dispersion on X-ray. The "rule of thumb" simply does not apply.

Commonly encountered radiological images:

1. The intact projectile
2. The relatively intact projectile with small detached lead fragments, often forming a trail
3. The relatively intact projectile with jacket separation
4. The deformed projectile — frequently seen as a "mushroom shaped" object
5. The "lead snow storm" pattern frequently seen with soft-point high-velocity projectiles
6. A tight cluster of lead shot
7. A loose dispersion of lead shot
8. Miscellaneous objects that mimic bullet wounds on external examination

The following images will provide an overview of the application of radiology as applied to wound or terminal ballistics.

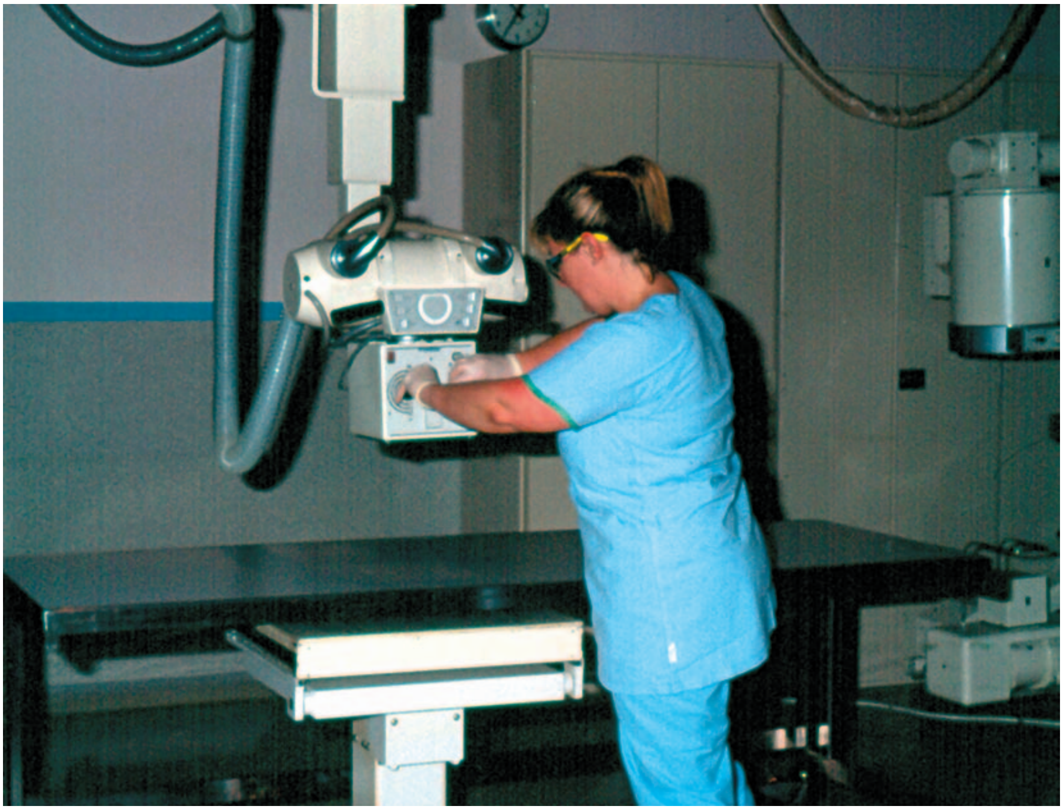


FIGURE 23.1 The gantry mounted X-ray machine employed as a routine in all gunshot victims at the Victorian Institute of Forensic Medicine.

FIGURE 23.2 The image intensifier is an instrument that is largely underutilized in the investigation of gunshot injury. A complete body scan can be performed in less than ten minutes.

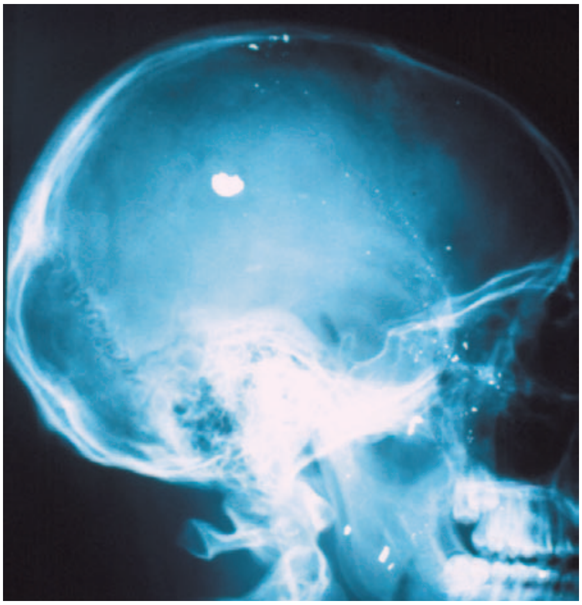


FIGURE 23.3 Lateral radiograph showing a relatively intact .22 cal projectile. Intraoral shot. Suicide. The .22 projectile typically does not exit the skull but tends to deform and often rebounds. Note small lead particles at vertex.

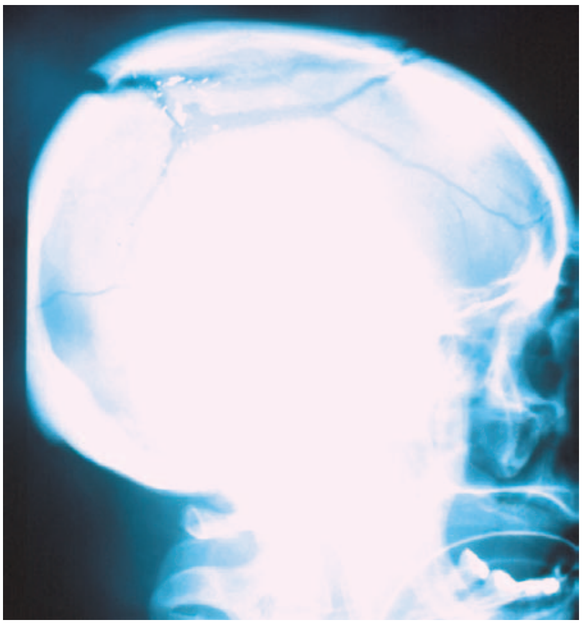


FIGURE 23.4 Extensive fragmentation of a .22 cal projectile. Note circular cranial defect (entry point) with extensive fracture. Suicide.

FIGURE 23.5 AP view of skull showing deformed .22 cal projectile fired from left to right. The bullet has undergone the typical "mushroom" like deformation.

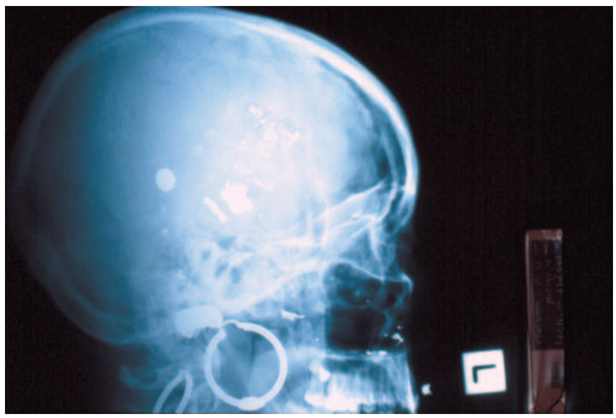


FIGURE 23.6 Multiple gun shots to the head. .38 Special. Homicide. The X-ray shows three large discreet fragments, some separated jacketing, and smaller lead particles.

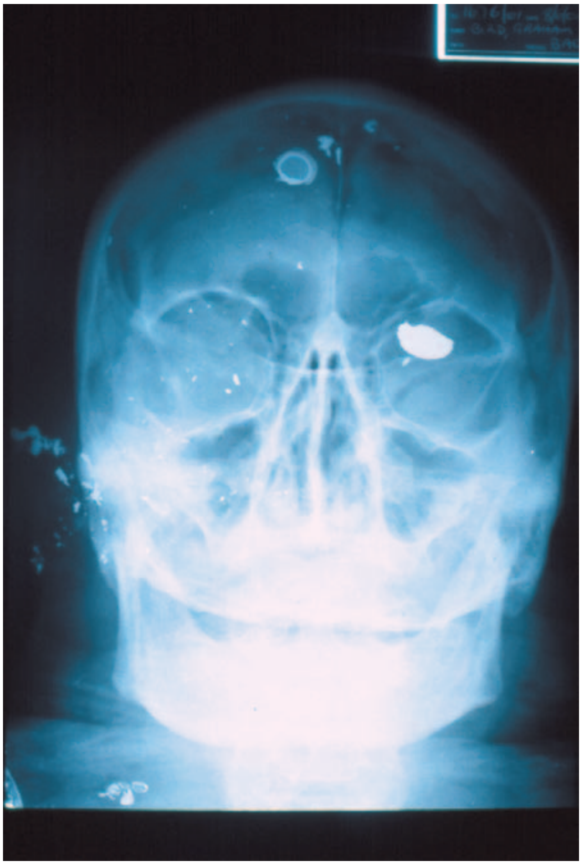


FIGURE 23.7 A classic radiograph showing a solitary intracranial .38 Special projectile fired through the right mastoid process. The jacket has completely separated and is seen above the right frontal sinus end on.

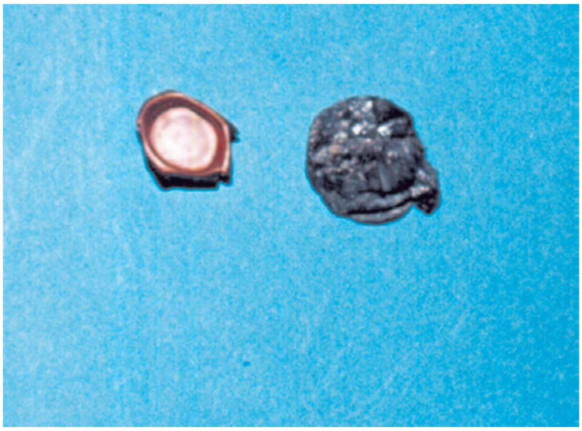


FIGURE 23.8 As above, the extracted deformed projectile and copper jacketing for direct comparison.

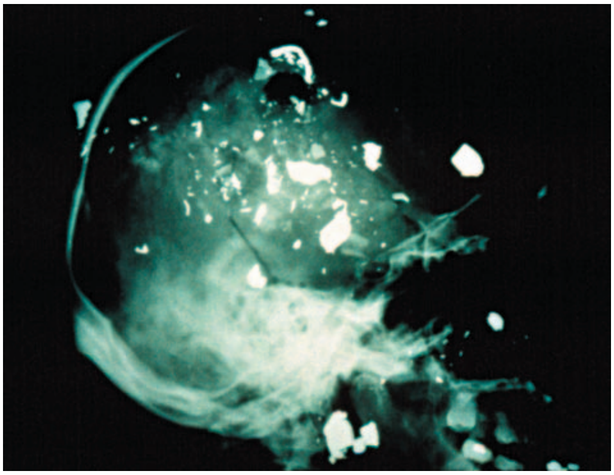


FIGURE 23.9 Multiple gun shots to the head. 9 mm projectile. Note extensive projectile fragmentation and cranial fracture.

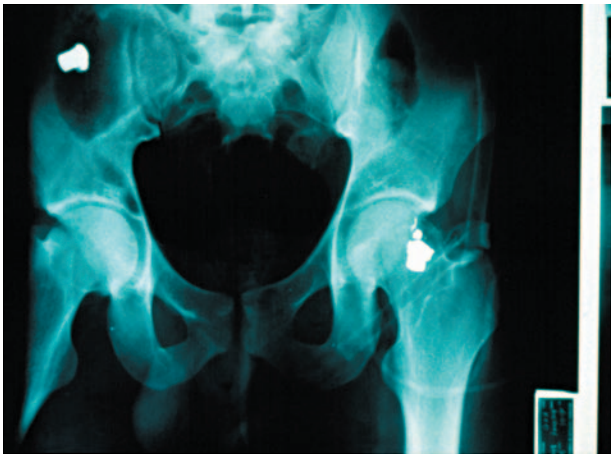


FIGURE 23.10 Radiograph showing two relatively well preserved and minimally deformed 9 mm projectiles. Homicide.

FIGURE 23.11 Chest x-ray showing multiple 9 mm projectiles. Homicide. Note a single .22 cal projectile at the lower left of the chest. This observation immediately indicates the use of at least two hand guns.

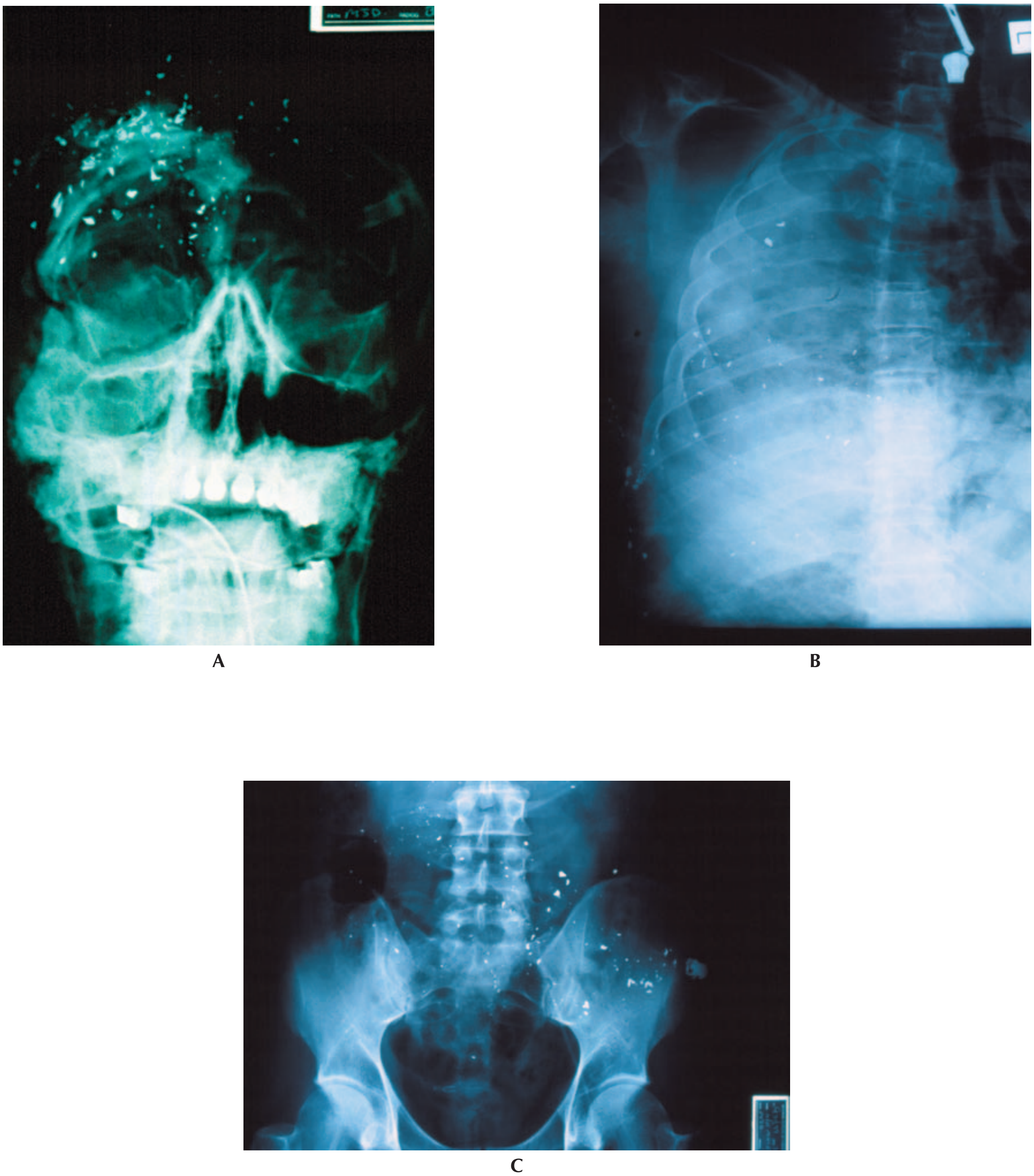
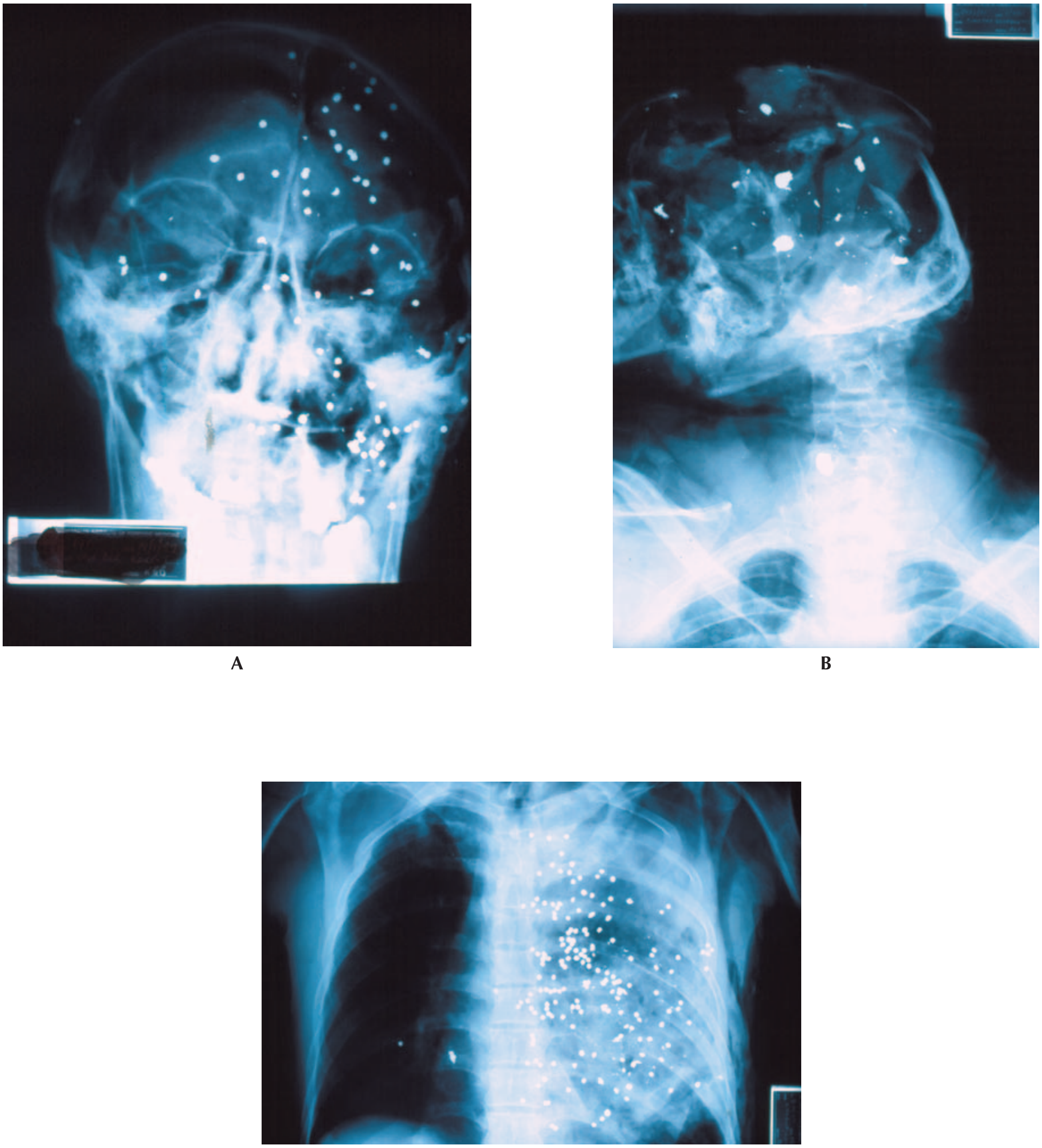


FIGURE 23.12 Typical “lead snow storm” appearance demonstrated in skull (A), chest (B), and abdomen (C) after high velocity projectile discharge. Note extensive cranial fracturing, which is entirely in keeping with trauma caused by this class of projectile.

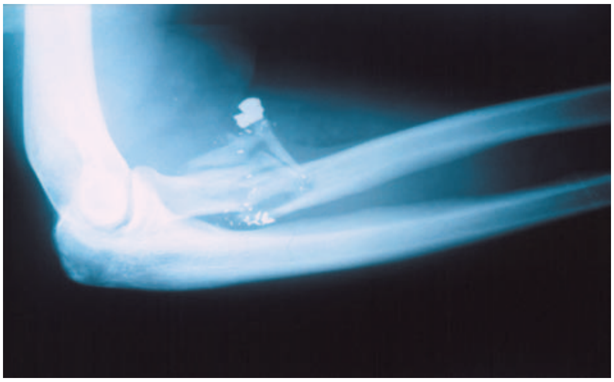


A

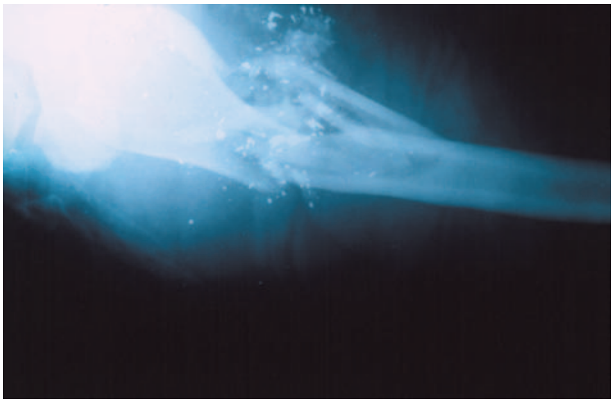
B

C

FIGURE 23.13 Typical examples of lead pellet dispersal after shot gun discharge. The upper image (B) show multiple buckshot pellets and extensive skull fracturing. Note strong resemblance to multiple shots after hand gun discharge.



A



B

C

FIGURE 23.14 Three images of trauma to long bones of the upper extremity and hand. 9 mm projectile. Homicide. The shatter and fracture pattern is typical of a higher velocity projectile. The trauma to the hand may be considered as a defense type injury.

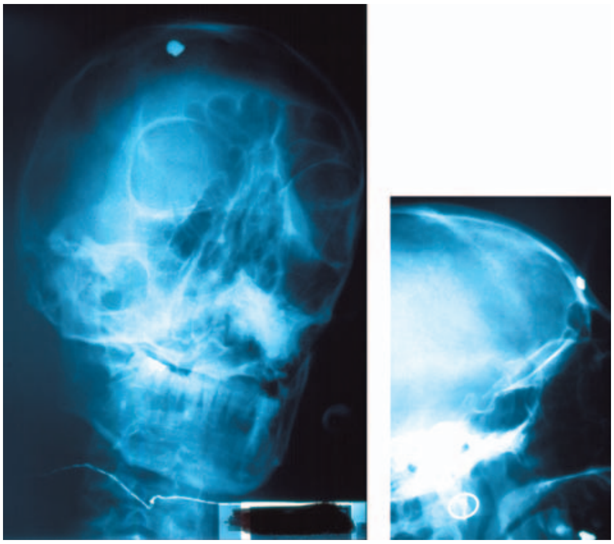


FIGURE 23.15 Air rifle pellet embedded into the frontal scalp. .177 cal. A.P. and lateral views submitted. These small pellets, typically weighing 8.2 grain, tend not to penetrate the adult skull but rather lodge in the subcutis. Full penetration may occur if the muzzle is placed over the squamous temporal bone or fired at the infant or adolescent skull.

FIGURE 23.16 The appearances of nails as fired from a nail gun. See chapter entitled "Nail Gun Injuries."

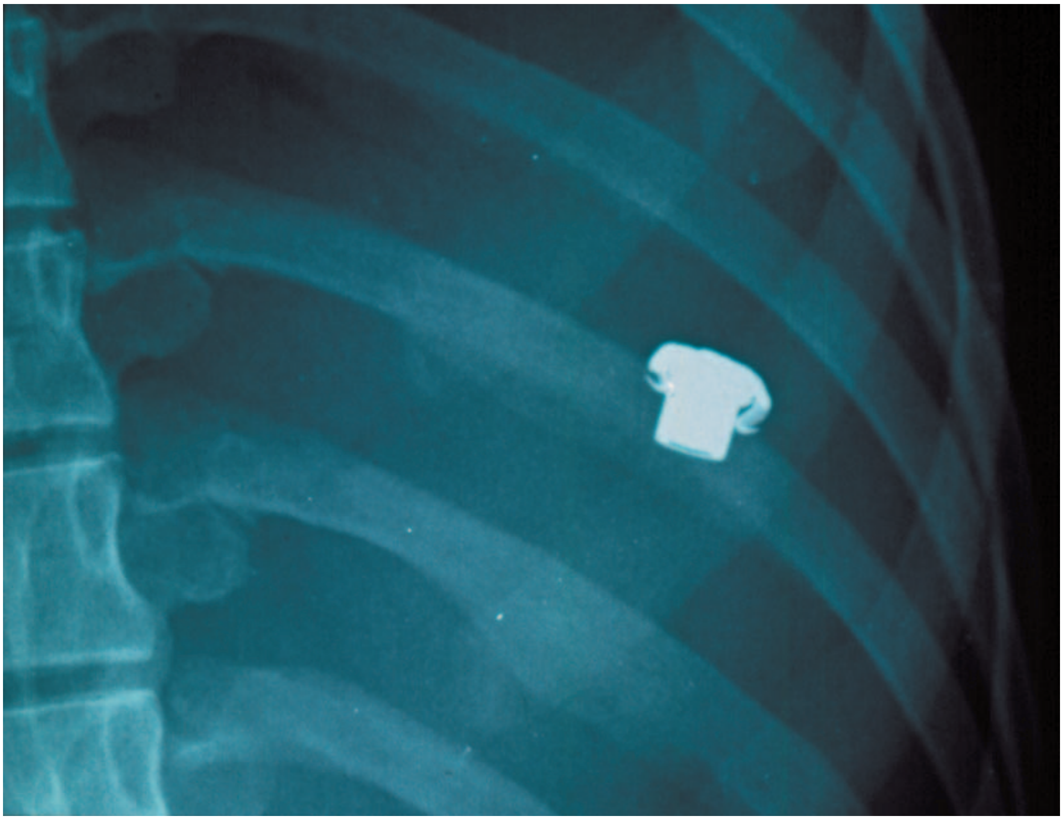


FIGURE 23.17 The typical radiological image of the spent black talon projectile. Note deployed pointed metallic hooklets. This object poses a definite risk to the examining forensic pathologist.

FIGURE 23.18 The Black Talon cartridge with spent projectiles at left.

24 The Gunshot Homicide—the Crime Scene

Personal attendance at the crime scene is the first important step in a successful investigation of a gunshot victim. It is my experience that all case attendances have something to offer, if nothing more than to foster good relationships between the office of the coroner, police, and specialist investigating agencies. In spite of what the media, television dramas, and novels might suggest, it is conceded that not all jurisdictions require the personal attendance of the forensic pathologist. In Victoria, the request for personal attendance is at the behest of the rostered investigating homicide squad.

In an ideal world, all homicide cases should require the attendance of a forensic pathologist and the majority do. However, in some cases, this may be more of an invitation "out of interest" rather than a formal request. Mitigating factors may include the distance of the crime scene locus from the Institute, the time of day, or more often, the perceived degree of case complexity.

Only a minority of cases require the immediate attendance of the forensic pathologist. At the time of "first call," be it at the office or at home, a brief outline of the scenario, number of victims, and estimated number of shots fired, type of weapon, good directions to the scene, and names of informants should be obtained and written down for later reference. Obtain a workable time frame from the informant. Useful information from the outset will help to rationalize the pathologist's work load and enable suitable safe travel time to the crime scene.

Make sure a current street directory and regional road maps are in the homicide vehicle at all times — this will prevent undue delays and potential embarrassment later. On rare occasions, an overnight stay in a country town may be preferable to a potentially sleep deprived and hazardous trip back in the early morning.

Once at the scene, the pathologist will be "logged in" by a crime scene officer, usually one of the local constabulary. The first "port of call" is to seek out the senior investigating member of the homicide squad and from him or her, obtain up-to-date information and developments.

Speak also to the photographic unit. Virtually all cases require full video recording of the locus of the body and environs, occasional aerial video and still photography, and certainly, room-by-room still photography. This process generally takes several hours.

Once all photography and video recording has been completed, it is appropriate for the forensic pathologist to be systematically taken through the crime scene and then to examine the body in situ.

The body cannot be moved or adequately examined before this process is complete.

Most cases do not require immediate autopsy examination. There is little to be gained from commencing a formal autopsy at 0400 hours unless specifically directed by a higher authority.

Make sure a representative album of crime scene photographs is delivered in a timely fashion to your office. A final review of these photographs should be undertaken prior to completion and release of the post mortem report.

The body can now be examined in situ. The body should not be unduly disturbed, save for rolling over and limited separation and lifting of clothing layers.

The pathologist may also wish to take photographs with his own camera equipment, or at the very least, request further photographs to be taken under his direction. Specific skin defects should be documented at the scene, with and without a photographic scale.

Rigor can be tested but it is strongly advised not to break rigor or separate the fingers at the scene. The forceful prying apart of fingers and doriflexion of the wrist at the scene may in theory aid in the loss of vital evidential material such as hair, clothing fragments and the artefactual redistribution of GSR. A clean white sheet of paper (with good lighting) should be placed under the hand and wrist to identify and "capture" any evidential material that may fall. The hands and distal forearms of the victim should be enveloped in plain brown paper bags and sealed to the forearm with tape. Do not use plastic bags as these encourage fluid collection from condensation which may obscure particulate evidence later.

If a full body search is preferred in situ, this should be performed by the pathologist and not the attending homicide squad. The taking of swabs and finger prints should be deferred prior to autopsy. In rare circumstances, body temperature estimation may be requested. This too should be deferred until the time of admission to the mortuary, as long as environmental temperatures have been recorded.

The weapon involved and spent casings may or may not be present. If present, the caliber should be ascertained from the ballistics expert at the scene. Do not handle the firearm directly. Acknowledgement of the caliber (and perhaps the projectile type) will be vital in suggesting whether the bullets may be within the body or may have exited. If the latter is evident, a dedicated search can include all immediate surfaces such as floors, ceiling, walls, and perhaps subjacent soil. The ballistics expert should preferably obtain gunshot residues (GSR) before the autopsy.

Do the findings at the scene corroborate the scenario postulated by the police?

Is the apparent suicide a concealed (or missed) homicide?

Has the scene been tampered with by a third person to simulate suicide?

If any doubts are present in the mind of the pathologist at the scene, it is better to air them immediately than to lose the opportunity (and the scene) later. If this is done in a purposeful and professional manner, no respect will be lost, and occasionally, a "win" will be produced that may change the entire complexion of the case. A putative estimate of the number of shots, range, and angle may be given "off the record" if pressed by the investigators.

In most cases, the crime scene locus is less than ideal for an examination that will address these pressing questions. It is best to defer until the autopsy is complete. There is often a tendency to say "too much too soon" at the crime scene. It is better to have all post mortem findings at hand before problematic cases can be commented on. A significant and early miscall may jeopardize and misdirect the course of the investigation, with drastic consequences later.

A full and personal examination of the locus by the pathologist will provide a better impression and interpretation of other intercurrent trauma such as bruises, abrasions, and non-gun-related lacerations.

Could the victim have fallen on to furniture or against the wall prior to death? The blood spatter patterns (if present) may aid in the interpretation of the movement of the victim in the moments before death.

Are the underlying factors of intermediary targets operative?

Examine all surfaces for the effects of primary bullet impact.

The obscure and indeterminate wound may be fully explained on the basis of passage through an intermediary target or after ricochet.

Pitfalls are always present.

Massive blast effect from smooth bore weapons, or heavy calibre guns at close range may mimic nonspecific blunt trauma.

Hair matted with blood will effectively mask the entry or exit of a small caliber projectile.

Gunshot as a cause of death may not be entertained until such time as the body has been fully X-rayed at the mortuary, or indeed after the opening of body cavities.

Before leaving the scene, it is good practice to document a brief outline of the sequence of events, findings, and conclusions based on the information immediately at hand. This can be done by the taking of notes or from dictation into a handheld recorder in real time.

Although the "fine print" of initial impressions may not be included in the final report, specific questions have been asked in a court of law regarding the taking and handling of information at the scene. At the very least, good data procedures constitute a valid "*aide memoire*."

It is my personal practice to include a one or two paragraph *precis* of the crime scene examination and agencies encountered at the beginning of my autopsy report.

Be mindful, however, that the forensic pathologist is not a crime scene investigator per se and that all sequential information will have/should have been collated by other specific agencies at the scene. This salient point can be made if pushed under rigorous cross examination during committal or trial.

The following real case scenarios will help to outline the unfolding of the investigation of gunshot homicide.

CASE 1

In mid June of 2000, the fully clothed body of a young man was found lying in a supine position on a bike track, an area rarely used by passersby. Initial impressions from the attending homicide squad strongly suggested that the deceased had been stabbed in the chest. This impression was made from the observation of a heavily blood stained T-shirt on the body. Attendance at the scene was more of an option given to me, the homicide squad being happy for the post mortem to be performed later that day. After full aerial, video, and still photography had been completed, I was able to closely examine the body.

A small "through and through" defect was identified at upper mid chest and back levels respectively. Close examination of the outer garments (mercifully very dark in color) showed the telltale residues of unburnt propellant. Further examination (without cleaning the body) showed typical tattooing or stippling on the neck and left side of the face of the deceased. This was a single shot fired at intermediate range, not a stabbing as first thought.

The impression after examination of the dispersal of powder residue and clear "through and through" trajectory was that a high velocity round had been fired — perhaps from a hunting rifle. This impression was vindicated after total body X-ray and full autopsy as outlined in the next chapter.

FIGURE 24.1 Aerial video recording and still photography of a crime scene is now becoming routine. A patrol car is seen in the foreground.

FIGURE 24.2 The body in situ lying on the bike track. The body must not be moved until all photography is completed. Note numbers on the ground indicating sites of potentially important evidential material.

FIGURE 24.3 A close view of an obvious defect through the upper anterior aspect of the T-shirt. This was originally thought to be a stab wound.

FIGURE 24.4 Careful examination of the dark parka showed fine particulate material in keeping with unburnt propellant. Further examination disclosed tattooing (stippling) to the neck and face areas.

FIGURE 24.5 Clues at the scene. A fresh tire treadmark is present in mud in close proximity to the body.

FIGURE 24.6 A cigarette butt lying in a pool of blood. DNA may be obtained from this exhibit. All items of evidential material should be photographed in situ, collected and bagged separately for later examination.

CASE 2

Late on a March evening in 2001, residents of an inner suburban area heard five to six possible gunshots. There was also the suggestion of some shouting prior to the gunshots. A local resident took it upon himself to explore a nearby park that backed onto his home. The body of a fully clothed male was found in a supine position. A large amount of blood was noted near the head. Several immediately obvious gunshot injuries were noted to the right side of the head. The nature of these wounds strongly suggested a hard contact discharge. A further well demarcated circular defect was noted through the mid upper lip. A possible exit wound was noted behind the left ear. After full video recording and still photography, the body was able to be moved. A further defect was noted through the upper garments; there was no apparent exit. No spent cartridge cases were located, suggesting that a revolver had been used. One could not exclude the use of a semiautomatic pistol, although given the reduced lighting at the scene, the likelihood of an assailant diligently searching for and picking up spent cases seemed remote.

As luck would have it, I was able to identify a deformed unjacketed lead projectile in nearby gravel, adjacent to the body. This appeared to be the projectile from the exit wound behind the left ear. The projectile resembled very closely that of a fragment of crushed rock that comprised the surface of the walking track through the park. I put this lucky observation down in part to being able to readily identify lead projectiles from dirt and gravel in the target areas of my local pistol club. Several other reasonably intact unjacketed projectiles were recovered at autopsy, all being quite suitable for examination by the ballistics team.

The complete autopsy examination disclosed the passage of four (and possibly five) independent gunshot discharges. The tentative fifth shot (passing through the left upper arm) had the characteristics of a defense type injury. This shot could not be confidently divorced from the shot to the mid face. The last (the sixth) projectile was found lodged in the back wall of an adjoining property.

FIGURE 24.7 The body as found. Flood lights had been brought in to adequately illuminate the scene.

FIGURE 24.8 A further view of the body at the scene. Note that there is a large amount of blood near the head. Some fine blood spatter is present away from the main pool at the right of the photograph. This corresponds to an exit wound behind the left ear.

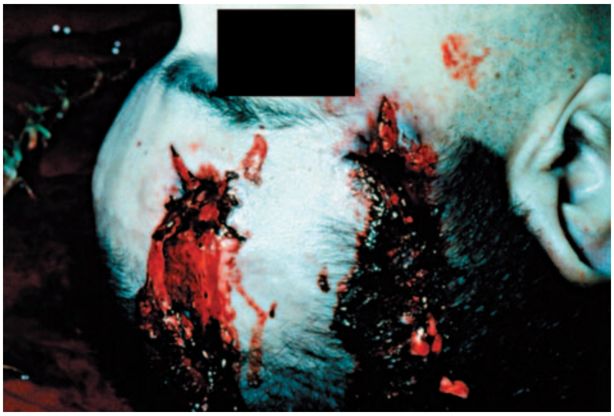


FIGURE 24.9 A close view of two of the bullet entry wounds as identified at the scene. The defects show typical stellate splitting in keeping with hard contact discharge.

FIGURE 24.10 A lucky find. A deformed unjacketed projectile is found lying among crushed gravel.

FIGURE 24.11 As above, the same projectile as photographed in the ballistics laboratory. Useful studies on rifling marks can now be performed.

25 The Gunshot Homicide — the Autopsy and Report

Why perform an autopsy on a victim of gunshot? From the outsider's point of view, it could be strongly argued that the cause of death is self evident. The family of the deceased may also hold this view and indeed, may occasionally raise a formal objection to autopsy. However, investigating police agencies, the coroner, and the law courts ultimately will demand answers to certain key questions. The counsel for the defense will also require a detailed report before a viable case can be made on behalf of his client.

These key questions include:

- How many shots were discharged?
- How many shots in fact hit the victim?
- From what range were the shots fired?
- From which direction and angle?
- What was the ultimate cause and mechanism of death?
- Could the victim have survived the impact of the projectile(s)?
- What role, if any, has the presence of natural disease, alcohol, or drugs played in this event?
- Could the victim have mounted any meaningful response or action after being shot?
- What were the victim's chances of survival if medical help was immediately available?

There are probably many other questions and considerations that may not be readily apparent at the time of initial investigation, or later at autopsy. The "bottom line" is to provide and collate all possible data so it can be used by any agency or interested party at any time in the future. It is only after the performance of a complete (versus limited) autopsy examination that these requirements can be met.

The autopsy must be performed in a time frame appropriate to the urgency and complexity of the case.

Some shooting scenarios can be described as "routine" while others are as seen as urgent and require autopsy at a time soon after the discovery of the body. I am always guided by the needs of the homicide squad, who ultimately have control over the case.

THE AUTOPSY

The examination must be performed in a well lit and equipped facility. The ideal and modern department will have a purpose built observation bay, either on an elevated tier or behind glass.

It is conceded that many examinations are performed in less than satisfactory conditions and occasionally in makeshift ones, but the final goals are the same and the gravity of the situation is certainly no less.

Who should be present at the autopsy? Essential personnel include the forensic pathologist, the mortuary technician, the photographer (ideally the same person who has attended the crime scene), and a member of the ballistics investigation team. Staff and observers should be kept to an absolute minimum. It is considered normal practice to have one or more members of the homicide squad as observers.

Discussions should be kept to the immediate matters at hand. Small talk should be kept to a minimum. As the case and examination unfold, it is important that direct dialogue between pathologist and police occurs, as well as with the police observer(s) and others remaining at the scene, or in the interview room.

There are several essential steps in the performance of a complete autopsy as applied to the gunshot victim.

1. The body, at time of admission to the mortuary, should not be stripped or searched. All duty staff should be aware of this requirement.
2. A video impression should be made as part of a permanent archive at the time of admission to the mortuary. This simple step often saves embarrassment later, if some basic facts regarding hair color, clothing type, etc. are queried.
3. Gunshot residues should be taken at this time. It is best to liaise with the ballistics department early in the development of the case, so essential examinations such as this do not impede the autopsy examination later.
4. Total body radiological examination is mandatory. It is advised that conventional X-ray plates be taken as these provide an excellent source of evidential material that may be used later in a court of law. The image intensifier may also

be employed for a general overview of the body prior to autopsy.

5. The body is transferred to the post mortem room and photographed from all sides with clothes in situ. Generally, a long and plan view are required. Essential views include the right lateral, left lateral, anterior, and posterior, with a close view of the face of the victim.
6. A full description is then made of clothing items, with due regard to size, brand name, style, and color.
7. All defects caused by projectile entry, exit, or graze are documented with reference to both anatomical and clothing structure landmarks. Closeup photography is performed, with and without scale.
8. Careful examination of the outer garments may disclose the presence of unburnt propellant, soot, and focal thermal effect. All positive observations are documented. Some authorities advocate radiological examination to disclose fine particulate lead residues and particles.
9. The clothing is carefully removed layer by layer and all defects in continuity described accordingly.
10. The naked body can now be rephotographed from the same angles as described previously. All areas of trauma should now be rephotographed. Close views are taken, with and without a scale.
11. The stripped body can now be examined in the normal way, with due regard to distinguishing marks and features. All scars and tattoos should be accurately described. To avoid repetition, the reader is referred to a copy of a complete autopsy report at the end of this chapter. The body is examined and described under the general headings of head and neck, chest, back, upper and lower extremities, and genitalia. Relevant negatives should be included. Swabs, hair, nail trimmings and other external biological samples may be taken at this time. All samples should be individually bagged and itemised on a suitable chain of custody transfer record sheet. All medical and surgical paraphernalia must remain in situ and must be accurately described.
12. Most gunshot homicide post mortem examinations are performed well before routine hepatitis and HIV serology results are at hand. It goes without saying that all due precautions must be taken during the handling of the body and certainly during internal examination. The degree of protection will be dictated by the standing orders of the facility and of course, by the personal preferences of the pathologist.
13. All trauma must be described in relation to well defined and recognised external anatomical landmarks. Obvious entry, exit, and grazes should be described in real time, using both a handheld recorder and a body chart for later reference. This will avoid "the worst case scenario" of a failed recording or the loss or receipt of poor quality photographs. Measure the location of the defects in terms of distance from the heel, top of head. and body midline.
14. The presence of abrasion rims, tattooing (stippling), grease rims, sooting and thermal effect are recorded. Measure the size of the defects with an accurately divided rule or micrometer.
15. The body can now be washed gently with a sponge and warm water. Any further wound details exposed can now be detected, documented, and photographed.
16. The simple entry without exit or "through and through" defect can be described as above. Multiple gunshot defects are best numbered and photographed accordingly. Several options exist. I have used, over the years, water soluble marking pens (with often disastrous results) and adhesive dots with numbers, but have found the best and most dependable method is the use of an indelible black marking pen after first drying the skin with alcohol. Constant moving and rolling of the body to check and recheck positions of defects and passage of projectiles will often blur the numbers, as the body and post mortem table are never completely dry. A suitable solvent will ultimately remove the numbers from the skin prior to discharge of the body to the undertaker.
17. The internal examination can now be performed. By convention, the brain should be removed first. This will decompress the vasculature of the neck prior to a dedicated neck dissection and will avoid the Prinsloo and Gordon artefact.
18. The use of probes prior to internal examination of the body is to be avoided. There is always the risk of creating false tracks. Probes, however, are of use later to demonstrate bullet trajectories into and through organs from the relevant skin defects.
19. All blood collections (if present) in pleural, pericardial, and peritoneal spaces are collected and measured.
20. The remainder of the examination is performed in a routine fashion. The organs are best removed as a block; this preserves all anatomical

relationships up until the time of individual organ dissection. All organs are weighed and relevant sections are taken for histology.

21. A full range of toxicology specimens are taken during this process. Specimens should include blood (leg vein and heart), vitreous, urine, bile, stomach contents, and liver. Cavity blood is to be avoided if at all possible.
22. During the examination, the pathologist will be able to determine the exact number of shots fired and their trajectories. An impression may already have been made after viewing the X-rays prior to the commencement of the autopsy.
23. All projectiles and jacketing recovered should be placed in individual containers, labelled as to the anatomical site of recovery, and handed to the ballistics expert.
24. Always use plastic forceps, never metallic ones. The risk of damaging, etching, and scraping the soft lead projectile is ever present. Do not, as some books advocate, etch numbers on the base of the projectiles. If a bullet is embedded in bone, it is best left in situ and the block of bone resected. The bullet can be separated at a later time under ideal conditions.
25. The characteristics of the projectile should be described in detail. The bullet may be intact, fragmented, or deformed. The jacketing, if present, may have partially or completely separated from the lead core. All fragments should be photographed in situ (with the use of an arrow) and after removal, against a neutral background.
26. If lead shot is present, a representative sample is to be collected (say 10 to 20 pellets) and all wadding, piston fragments, and amorphous debris retained. Always try to identify clothing strands and any foreign material that may have entered the bullet track.
27. Photographs of internal organ damage should be taken. These are not generally shown to jurors in a court of law, but are certainly useful for later reference and cross checking before the final report is released by the pathologist.
28. There is a strong case, at least in some circumstances, to resect the putative bullet entry defect for histological examination. The presence of soot and unburnt propellant may help to resolve the question of range of discharge and entry versus exit if this is in doubt.
29. The examination is now complete. The organs can be returned to the body and reconstruction can now be performed by the mortuary technician.
30. The body should not be released immediately. It is prudent to retain the body for a further 24 to 36 hours. Bruising not seen on the first external examination may be quite obvious later. The opportunity now exists for additional descriptions to be made.
31. All organ weights and the details regarding bullet number and passage should be written down on the body chart for later reference.

The following series of photographs relate directly to Case 1 as detailed in the previous chapter, "The Gunshot Homicide — The Crime Scene."

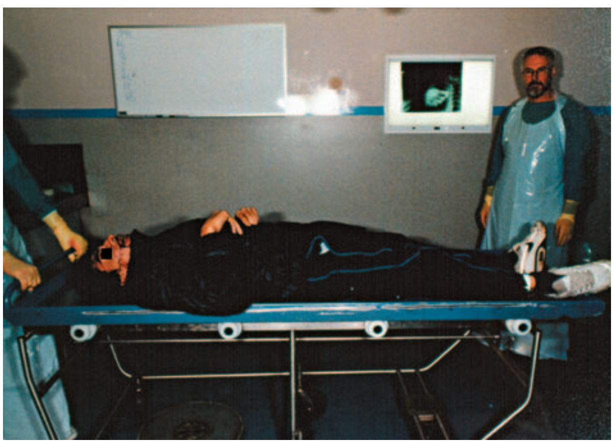


FIGURE 25.1 The body is photographed with all clothing items and medical paraphernalia in situ. A full X-ray examination has already been performed.

FIGURE 25.2 All defects in clothing items caused by the passage of the projectile should be demonstrated. This photograph shows the point of entry with tandem damage to the adjacent teeth of the midline zipper. This observation accounts for the small secondary entry defect at the 11 o'clock position (see report and later images).

FIGURE 25.3 The jacket as viewed from the back. Note well defined exit defect with partially extruded insulating material.

FIGURE 25.4 Close view of extruded insulation material from "puffer jacket." The direction of the extrusion of the fibers greatly assists in the determination of the direction of passage of the projectile.

FIGURE 25.5 Close view of entry point through the anterior aspect of the T-shirt. One large defect and several smaller "satellite" defects are noted. This may represent either detached zipper teeth, or partial bullet jacket separation, or both.

FIGURE 25.6 Close view of solitary exit defect through the back of the T-shirt.

FIGURE 25.7 The body, once stripped, is rephotographed. All trauma is documented with reference to anatomical landmarks.

FIGURE 25.8 In this case, stippling (tattooing) is noted 300 mm radial to the entry defect. The shadow effect of the collar of the jacket and T-shirt is obvious.

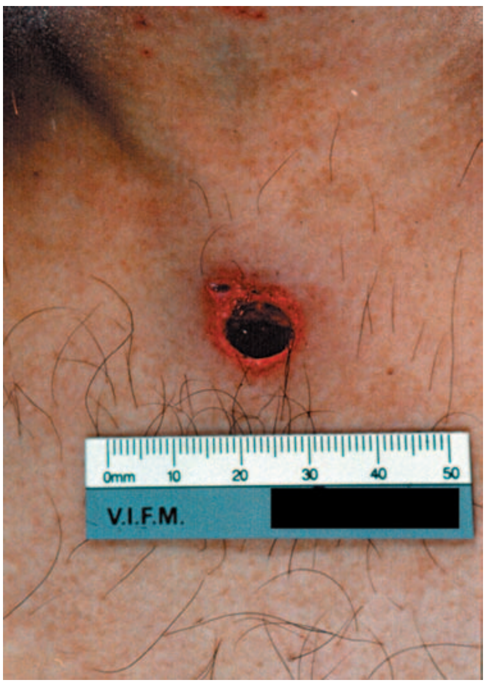


FIGURE 25.9 Close view of entry wound to upper mid chest. A well defined abrasion rim is noted, as well as a smaller defect at the 11 o'clock position. Stippling can just be seen over the mid anterior neck and left side of face.

FIGURE 25.10 Close view of exit defect. Note a degree of eccentric abrasion in keeping with a shored exit. The heavy supporting clothing may account for this phenomenon. Equally, firm ground beneath a supine body will produce a similar picture.

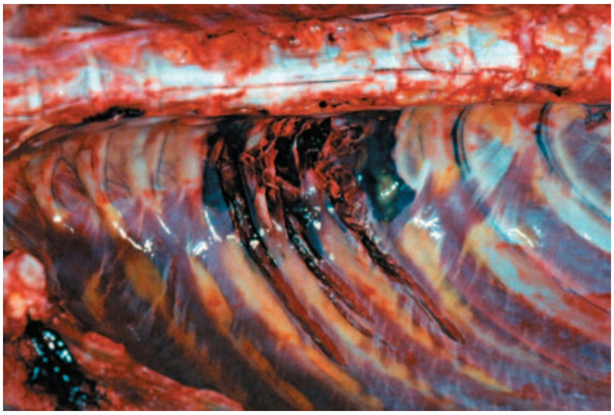


FIGURE 25.11 The point of exit through the posterior wall of the right hemithorax. Note shattering of the eighth and ninth ribs and regional intercostal haemorrhage.

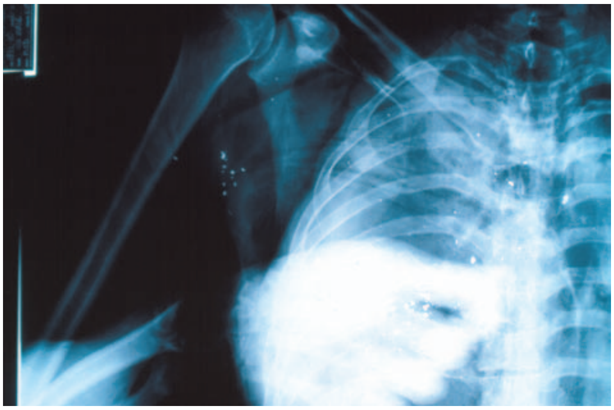


FIGURE 25.12 Pre post mortem radiograph showing the tell-tale "lead snow storm" trail of a high velocity projectile.

THE REPORT

The autopsy findings should be dictated at the end of the examination, not the following day because small details may be lost to memory and time. The initial report can be dictated in less than 30 minutes. Some time later, histological preparations are examined and toxicology reports become available; both can now be integrated into the report. Final comments can now be made and hopefully, most of the questions posed in the preamble can be addressed with confidence.

The *style* of the report is obviously governed by the personal preferences and idiosyncracies of the pathologist. The report can be as brief or as detailed as needed, providing all essential information is documented and key questions addressed.

How much is too much? It is my view that it is better to err on the side of being "too wordy." With time, details of organ damage and relevant negatives (often first asked at time of inquest or committal) may be forgotten. Credibility "goes out the window" if the pathologist, once in the dock, is forced to admit that he cannot recall if a certain feature was present or a certain sample was or was not submitted. It is best, in my view, to detail everything in the final report, especially the fine detail of intercurrent natural disease.

Although this report is a medicolegal document, the final cause of death and comment should essentially be a common sense or plain language statement that ought to be interpreted by the medically untrained person. Statements such as "the bullet travelled upwards, backwards, and slightly to the right" are more meaningful than the projectile passed "posterosuperiorly and in a right lateral direction." We must remember that the legal fraternity, although often very familiar with medical jargon, is not medically trained.

This is one benefit perhaps of the medical examiner system over the process of coronial enquiry. It is often useful to briefly document the scenario of the event at the beginning of the report. Document all special techniques employed and all samples taken.

Some pathologists prefer to document in one complete section, the entry, passage through soft tissues, organs and bone and exit of the projectile and this approach has great merit. As the examination is, however, performed in stages (from external to internal), it also makes sense to document entry characteristics on external examination and then document the passage of the projectile, by virtue of the damage incurred, organ by organ, as set out in the autopsy proforma.

Although requiring more work, I employ this strategy, dealing with heart, lungs, liver, musculoskeletal system, etc., separately but I then include a separate section near the end of the report (generally prior to the histology comment) entitled "path of projectile." This outlines the passage of the bullet from entry to exit and all structures in between in a "summary" style. This section can now be read verbatim in a court of law and at once details the effects of the shooting for the jury — leaving little doubt in their minds as to the effects of the shots fired. The cause of death (and manner of death if required) can then be listed prior to final comments. The section entitled "comments" can then address the key questions in order.

Undoubtedly there are many alternate ways of documentation, and as stated previously, it essentially boils down to individual style. What works for one may not necessarily appeal to another.

A complete report now follows as a working example of a real case under investigation. This report relates directly to Case 1 as described in chapter 24, The Gunshot Homicide — The Crime Scene.

To ensure anonymity of the deceased and the names of the personnel involved in this investigation, certain pertinent details have been deleted.

AUTOPSY REPORT

MALCOLM J. DODD on his oath saith — I am a legally qualified Medical Practitioner. On the ____ day of June 2000, at 1700 hours, at the Coronial Services Centre, Southbank, I performed an autopsy on a body whom I believed to be

Forensic Technician

Observers

Photographer

At 1315 pm on the day of ____ June. 2000, I attended a crime scene at the intersection of

I was met at the scene by (Homicide Squad) and members of the scene investigation unit and crime scene photographers.

I was shown the body of a fully clothed deceased male lying near a bicycle track, in the supine position.

Death was pronounced at 1330 hours.

Initial inspection showed evidence of a single gunshot entry wound to the upper mid chest.

There was evidence of stippling (tattooing) over the face and gun powder residue over the anterior aspect of his parka.

A single exit wound was noted through the upper mid back of the parka.

A small amount of blood was present beneath the body.

EXTERNAL EXAMINATION

The body is that of a well nourished male of olive complexion, of staged age, years.

The deceased weighs kg. ____ and measures ____ cm.

The body is received fully clothed.

The clothing comprises:

1. A heavy black parka with elasticised cuffs, fully zipped at the front (Brand — Banana Republic).

   Close inspection reveals a fine dispersion of white-yellow minute particulate fragments suggestive of unburnt propellant over the upper thigh and left anterior aspect of the parka.

   At a point approximately 60 mm below the superior end of the zip, there is a poorly defined full thickness irregular defect through the garment immediately adjacent to the right side of the zip measuring approximately 5 mm in greatest extent.

   Reflecting the garment outwards discloses a ragged irregular defect with protruding insulating fibre fragments extending inwardly.

   Examination of the posterior aspect of the garment shows a ragged irregular defect with extruding insulating material more or less in the midline at a point approximately 190 mm inferior to the mid of the back of the collar.

   The right inner pocket contains six hundred and fifty dollars in notes comprising three × one hundred, four × fifty, seven × twenty and one × ten denomination notes.

2. A yellow T-shirt with USA, the American Flag and Russell Athletic USA below it is in place showing extensive blood soaking of the anterior and right shoulder and arm aspect of the garment.

   At a point approximately 30 mm from the mid of the anterior collar, a ragged irregular 12 mm defect is identified.

   Inferior and to the left of this, two smaller defects are identified each measuring approximately 6 mm in greatest dimension.

   Two smaller holes (3 and 2 mm in diameter respectively) are noted to the immediate right of the main defect.

   Examination of the posterior aspect shows extensive soaking of blood involving almost the entire back of the garment.

   A solitary 15 mm diameter defect is present at a point approximately 200 mm inferior from the collar and 60 mm to the right of the midline.

3. A pair of navy blue tracksuit pants (Brand — Nike) with two light blue stripes on each lateral aspect of the leg with the lower legs showing zips, fully fastened.

4. Twenty four cents is present within the right hand pocket of the tracksuit pants.

5. A pair of charcoal grey and navy-blue underpants (Brand — Vibes).

6. A pair of white and navy-blue runners (Brand — Air Max).

7. A pair of light blue socks (Brand — Jag).

   Between the right sock and runner a small cellophane plastic package containing an aggregate of white powder is identified.

Personal Items

1. Quartz digital wrist watch with dark blue rubber wrist band (Brand — Alpha Project) showing correct time.

2. Gold earring through left lobe.

Distinguishing Marks and Features

Head and Neck

1. The hair is long, dark, and slightly wavy.

2. There is a closely cropped black goatee beard and moustache.

3. The irises are dark brown.

4. There is no evidence of scleral icterus, subconjunctival or petechial hemorrhage.

5. The external nares contain clotted blood.

6. The external auditory canals are unremarkable; the left lobe shows cosmetic type piercing.

7. Close inspection of the inner aspect of the left external auditory canal shows evidence of stippling (tattooing).

8. The upper and lower dentition are natural and in fair condition.

9. The tongue and buccal cavity are heavily coated with liquid blood.

10. The frenulae are intact.

11. Inspection of the facial skin shows a broad dispersion of fine particulate abrasions each measuring less than 1 mm in greatest extent.

    The dispersion of stippling (tattooing) involves almost the entire left side of the face with sparing of the right cheek area.

    The extent of stippling measured from the bullet entry wound (see later) is approximately 290 to 300 mm in radius.

Chest and Abdomen

1. Examination of the chest shows a solitary well demarcated full thickness circular defect measuring 10 mm in diameter.

   The defect has a clearly demarcated abrasion rim measuring approximately 1 to 2 mm in maximal width.

   There is no evidence of regional thermal effect or stippling.

2. At a point approximately 11:00 o'clock as seen anteriorly, there is a small secondary entry defect measuring 2 mm in diameter. This small secondary defect is also surrounded by a narrow abrasion rim.

3. The primary entry defect resides immediately below the jugular notch, 330 mm to the top of the head and 1430 mm from the heel.

4. The remainder of the abdomen shows no apparent evidence of trauma or past surgical intervention.

External Genitalia

1. The penis is circumcised.

2. There is no evidence of trauma.

Left Upper Limb

1. Inspection of the antecubital fossa discloses two minute areas of crimson pigmentation, suggestive of old injection sites.

2. There are no distinguishing marks or scars.

Right Upper Limb

1. Inspection of the right antecubital fossa discloses several poorly defined lilac areas of discoloration consistent with old injection sites.

2. There are no distinguishing marks or scars.

Left Lower Limb

1. A well healed curvilinear 50 mm scar is present above the knee.

2. Several small irregular scars are present over the shin.

3. A well healed oblique oriented 60 mm scar is present on the medial aspect of the thigh.

Right Lower Leg

1. A well demarcated and healed elliptical scar measuring 45 × 35 mm is present on the medial aspect of the lower leg.

Back

1. Examination of the back shows a solitary exit defect measuring approximately 10 mm in diameter with an area of abrasion extending inferiorly to maximum of 10 mm in width (consistent with a shored exit).

   Close inspection shows several small radial splits at 12, 3, and 9:00 o'clock as seen in the anatomical position.

2. The defect is located 200 mm from the base of the neck and approximately 30 mm to the right of the midline.

The following signs of Medical Intervention are apparent:

1. Nil.

The following signs of Postmortem Change are apparent:

1. Rigidity is established in all limbs.

2. Lividity is patchy posteriorly.

INTERNAL EXAMINATION

CARDIOVASCULAR SYSTEM

Heart: 282 g. The heart shows normal size and contour. There is no evidence of trauma.

Pericardium: The pericardial cavity contains approximately 30 ml of liquid and clotted blood. An irregular laceration is present over the most superior and right lateral aspect of the membrane. There are no adhesions.

Epicardium: The epicardial fat is in normal distribution.

Myocardium: The left ventricular myocardium is uniformly red-brown and shows no evidence of old or recent infarct. The atria are unremarkable and intact; thrombi are not identified. There is no evidence of congenital structural abnormality.

Endocardium: Unremarkable.

Cardiac valves: The cardiac valves are normally formed and show no evidence of vegetation formation or calcification.

Coronary arteries: The right and left coronary artery ostia are widely patent and in anatomical location. All vessels show a uniformly smooth intima; there are no areas of significant stenosis. There are no anomalies.

Aorta and its major branches: The root of the aorta shows extensive transmural contusion but appears intact. The most superior portion of the arch aorta has been lacerated by the projectile causing extensive disruption of the regional intima typified by numerous irregular tears. The root of the right carotid artery is separated from the arch.

Mediastinum: A moderate amount of anterior mediastinal haemorrhage is identified.

RESPIRATORY SYSTEM

Pleura: The right pleural cavity contains 1400 ml of liquid and clotted blood. The left pleural cavity is empty.There are no adhesions. The right lower lobe pleura is extensively lacerated. The posterior parietal pleura on the right side shows extensive disruption as a component of the gunshot exit injury (see later).

Larynx: The larynx and hyoid bone are intact and unremarkable. There is no evidence of trauma to the overlying strap muscles.

Trachea and Bronchi: The mucosa is smooth and shiny. The lumen of the trachea, right and left main bronchi, and segmental branches contain a considerable amount of fresh blood. The right bronchus is shattered and detached from the carina.

Lungs: Right lung 458 g. Left lung 725 g. The visceral pleurae are crimson, mottled, and show minimal anthracosis. Separation of the right lobes shows extensive disruption at the hilum with a through and through injury involving the right lower lobe. Extensive intraparenchymal haemorrhage is present within the right lower lobe. The left upper and lower lobes show prominent congestion and edema.

Pulmonary Arteries: The right pulmonary artery is disrupted. There is no evidence of thromboembolism.

Diaphragm: Unremarkable.

GASTRO-INTESTINAL TRACT

Peritoneal cavity: The peritoneal cavity is clear of fluid and adhesions.

Esophagus: Intact and unremarkable throughout.

Stomach: The stomach is of normal size and shows a smooth serosa and a wall of normal thickness. The rugae are unremarkable. The lumen contains approximately 15 ml of opaque brown fluid. There are no mass lesions.

Mesenteries: Unremarkable.

Duodenum: Unremarkable. No evidence of ulceration.

Jejunum and Ileum: Unremarkable throughout.

Appendix: Present and normal.

Colon: Unremarkable throughout.

Liver: 1337 g. The hepatic capsule is smooth and shiny. The parenchyma is pale and uniformly tan-brown in colour. There are no mass lesions.

Pancreas: The external aspect and cut sections are unremarkable.

Gallbladder: The gallbladder is of normal size and shows a velvety mucosa. The lumen contains watery green bile. No calculi are identified.

Bile ducts: Unremarkable.

RETICULOENDOTHELIAL SYSTEM

Lymph nodes: Several enlarged firm pale lymph nodes are present near the porta hepatis.

Spleen: 188 g. The splenic capsule is mauve and wrinkled. The pulp is firm.

Bone marrow: The vertebral marrow is of red active type.

ENDOCRINE SYSTEM

Pituitary gland: Unremarkable.

Thyroid gland: Unremarkable.

Adrenal glands: Unremarkable.

GENITO-URINARY SYSTEM

Kidneys: Right kidney 145 g. Left kidney 134 g. The renal capsules strip readily revealing smooth surfaces. On section, the cortices are of normal thickness and the pyramids are well delineated. The renal pelves are unremarkable. Each kidney gives rise to a single ureter of normal calibre, inserting into the bladder in the normal fashion.

Bladder: The mucosa and wall are unremarkable. The lumen contains clear pale yellow urine.

Prostate: Unremarkable.

Testes: Unremarkable.

MUSCULOSKELETAL SYSTEM

1. Reflection of the skin of the anterior chest wall and subcutaneous tissues reveals a well demarcated full thickness 10 mm. diameter defect through the junction of the manubrium and insertion of the 1st right rib. There is extensive fresh regional subcutaneous and intramuscular hemorrhage subjacent to the entry wound.

2. The bullet has exited through the posterior right chest to involve both the eight and ninth ribs posteriorly with extensive shattering and regional hemorrhage. Finely dispersed metallic fragments are present within the entry and exit areas.

3. Subcutaneous dissection of the right antecubital fossa shows brown discoloration in keeping with an aged injection site.

4. Subcutaneous dissection of the left antecubital fossa discloses a similar appearance to the right.

CENTRAL NERVOUS SYSTEM

Brain: 1628 g.

There is no evidence of epidural, subdural, or subarachnoid hemorrhage.

The meninges are clear; there is mild meningeal congestion.

Serial coronal and sagittal sectioning of the cerebral and cerebellar hemispheres, respectively, fails to reveal macroscopic pathology.

The midbrain, pons and medulla are unremarkable.

The cerebral arteries and circle of Willis are patent throughout.

Spinal cord and spinal column:

1. The spinal cord was not examined.

2. The axial skeleton appears normal; there is no evidence of trauma.

Path of Projectile

The bullet has entered the upper anterior chest more or less in the midline (anatomically below the jugular notch) and has passed through the right first costosternal joint and manubrium.

The bullet has travelled inferiorly, posteriorly and to the right to exit through the right posterior chest causing extensive fracture and regional hemorrhage to the 8th and 9th ribs and intercostal soft tissues.

During its course, the bullet has passed through the arch of the aorta, completely severing the origin of the right carotid artery.

The bullet has then travelled downward to cause regional contusion and laceration to the pericardial cavity without causing trauma to the heart.

The bullet has then passed through the right bronchus completely separating the structure from the lung and has passed fully through the lung to exit through the posterior aspect of the right lower lobe.

A radiological examination of the chest shows an extensive "lead snow storm" like appearance of finely divided metallic fragments, predominantly within the right hemithorax and regions of entry and exit.

<u>SPECIAL INVESTIGATIONS</u>

1. Tissue taken for histopathological examination.

2. Full toxicology.

3. Macrophotography.

4. Radiology.

5. Biological exhibits and evidential material (nail clippings, hair, muscle, blood and rectal swabs, projectile fragments, white powder wrapped in cellophane and 650 dollars in varied notes) taken by _________ to FSL at 1935 hours on the 21st of June 2000 — see Chain of Custody Evidence Transfer Record).

RESULTS

(a) Histology

Heart: Unremarkable
There are no acute changes nor evidence of myocarditis.

Lungs: The pulmonary parenchyma shows congestion, edema and extensive intra alveolar hemorrhage. There are focal areas of alveolar airway collapse and expansion. Tobacco macrophages are conspicuous.

Liver: The parenchyma shows a pattern of low grade chronic active hepatitis.

The portal tracts show florid lymphocytic expansion and in many areas there is both spillage of these cells and evidence of piecemeal necrosis. There is also a component of lymphocytic lobular hepatitis.

Fatty change is minimal and predominantly of microvesicular type. The findings are in keeping with Hepatitis C infection.

Spleen: Reactive germinal lymphoid centres are conspicuous within the white pulp. The parenchyma appears congested.

Kidney: Unremarkable.

Prostate and testes: Unremarkable.

Endocrine organs: The pancreas is autolysed.
Remaining organs are unremarkable.

Lymph nodes: The lymph nodes are reactive and show enlarged germinal centers. Occasional giant cells with vacuolated cytoplasm are identified.

Bone marrow: The marrow is normocellular for age.

Brain: Unremarkable.

(b) Toxicology See attached report.

CAUSE OF DEATH

I(a) SINGLE HIGH VELOCITY INTERMEDIATE RANGE GUNSHOT WOUND TO THE CHEST

INCIDENTAL FINDINGS

1. Mild chronic active hepatitis. Hepatitis C.
2. Reactive and congestive splenomegaly.
3. Reactive lymphadenopathy.

COMMENT

1. The cause of death in this case is one of a single high velocity intermediate range gunshot wound to the chest.
2. External examination of the deceased showed a well demarcated full thickness through and through defect in keeping with a bullet entry wound to the upper mid chest and exit through the right posterior chest.
3. Inspection of the clothing and facial skin discloses a fine dispersion of particulate material and stippling (tattooing), respectively, indicative of an **intermediate range gunshot.**
4. The observation of a through and through wound coupled with a typical lead "snow storm" pattern on X-ray indicates that the projectile was of **high velocity** type, therefore fired from either a heavy caliber revolver or hunting rifle.
5. The mechanism of death in this case is one of acute blood loss as a result of the projectile passing through vital structures of the upper chest.

   A description of the passage of the bullet may be found on page 10 of this report under "Path of Projectile."
6. Natural disease in this case consists of mild chronic active hepatitis and Hepatitis C.
7. Hepatitis C is not uncommonly seen in intravenous drug users.
8. External examination of the deceased showed needle track marks on both right and left upper arms and a small package of white powder concealed in his right runner.
9. Toxicological analysis of body fluids reveals the presence of both morphine and codeine in blood.
10. Although beyond absolute proof, the combination of morphine and codeine is in keeping with the administration of heroin.
11. Radiological examination discloses the presence of a fine dispersion of lead particles over the entry and exit areas and upper thorax on the right side.
12. In addition, the X-ray examination discloses the presence of a comminuted fracture of the right distal radius and carpus.
13. A fracture such as this may be seen in cases of a fall or a landed punch.

External examination of the forearm and hand area showed no significant bruising, swelling, abrasion, or laceration.

14. The absence of external injury in tandem with obvious radiological fracture would indicate that the injury had occurred immediately prior to death.

15. Defense type injuries were not identified.

I hereby acknowledge that this statement is true and correct and I make it in the belief that a person making a false statement in the circumstances is liable to the penalties of perjury.

Malcolm John DODD, MB BS (Melb); FRCPA; DMJ(Path); Assoc. Dip. MLT; MACLM; AAIMLT; FACBS

Forensic Pathologist
Victorian Institute of Forensic Medicine

Acknowledgment made and signature witnessed by me at ________ am/pm on ________, the ______ day of 2000 at the Coronial Services Centre, Southbank.

Signature ______________________________________

Name ____

Office or Rank & Number ________________________

A prescribed officer class at the
State Coroner's Office, Southbank

26 Photographing Gunshot Injuries

Karen Byrne

INTRODUCTION

Accurate photographic documentation of gunshot injuries forms a vital part of the forensic examination. By following a few simple guidelines, it is possible to produce photographs that will assist the pathologist and the court, and that will provide important documentation for reflection at a later stage. As there is no definitive list of equipment required for accurate documentation, this chapter discusses the principles that should be applied to achieve optimum results with a varying degree of resources. These principles provide valuable advice but further reading and research will be required to gain a more comprehensive understanding of the theory of photography.

EQUIPMENT AND RESOURCES

Equipment is not an area in which to compromise as it directly relates to the quality of the resultant image. Expenses can vary but the quality of the equipment should fall within certain parameters.

The equipment and resources considered in this chapter include:

- Camera
- Lenses
- Light source
- Film processing

CAMERA

The camera of choice for most forensic work is a 35mm Single Lens Reflex (SLR) camera.

The viewfinder of a SLR camera has the advantage of allowing the photographer to see exactly what will appear on the film through the use of a pentaprism and a mirror. Cropping of potentially important information may occur on cameras not utilizing this feature. It is generally recommended to purchase a camera body from a manufacturer with a wide selection of interchangeable lenses, resulting in optimum flexibility.

While an automatic camera will suffice in many cases, the added control over the exposure that is possible with a manual camera is often invaluable. In addition, the camera needs to be sturdy and reliable with batteries and cleaning material readily accessible. Capturing certain images can be time critical and requires that the equipment be meticulously maintained.

LENSES

Purchasing quality lenses can substantially increase the quality of the final image. The following features warrant consideration prior to the purchase: the focal length, focusing range, maximum and minimum apertures, resolving power, and the compatibility with existing camera equipment.

Forensic photography requires a variety of focal lengths to document the overall body and close-up detail. This can be accomplished in two ways: using a single zoom lens or using a selection of fixed focal length lenses. With the former, the focus stays constant and the focal length changes. The convenience of achieving a range of focal lengths without changing lenses allowing for efficient documentation is attractive; however, the zoom lens has a drawback. Occasionally the photographer is required to know the focal length used to take a particular image and this is very difficult to ascertain when using a zoom lens. Because of the general superior quality, fixed focal length lenses are the preferred choice for forensic photography. A standard 35mm SLR camera kit should include the following lenses:

Wide-angle lens (such as 28mm or 35mm lens)
Standard lens (such as 55mm)
Close-up lens (such as a 105mm "macro" or "micro")

The words "macro" or "micro" describe a lens that has specialized optics for capturing close-up images.

LIGHT SOURCE

The two types of light sources used in forensic photography are natural light (such as direct sunlight) or artificial light (such as tungsten lights or electronic flash). In outdoor scene work a photographer may utilize natural light during the day; however, in low light or indoors, electronic flash is the best choice. Electronic flash is used almost exclusively in mortuary work as it is reliable, easy to use, and gives consistent results. Check that the camera, lens, and flash are Through The Lens (TTL) metering compatible. Although this is not a necessity, TTL is a convenient option. The flash unit should be powerful enough to enable the use of smaller apertures (for increased depth of field), while allowing for portability and greater battery duration.

A ring flash that attaches to the end of a lens is a useful light source when photographing cavities. However, these may not be as powerful as other flash units and tend to produce "flat" lighting, so they are best used as an adjunct rather than as the primary lighting source.

FILM/PROCESSING

The choice of film (sometimes referred to as the emulsion) will depend on the requirements of the end user. Slide film, for instance, may not be the best choice if the photographs are destined for the courtroom where prints are the usual format. Color images provide much more information than black and white and are therefore used most often; however, some special techniques such as infrared and ultraviolet radiation may require the use of black and white film.

FILM CHARACTERISTICS

Negative Film	May be color (resulting in a color print) or black and white (resulting in a black and white print). Print film has a greater exposure latitude than slide film and is therefore more forgiving of mistakes with exposure. A negative of the film is produced and then printed onto paper; this is a two-step process with some subjectivity in the printing process.
Reversal Film or Slide Film	Produces a slide or transparency. It is a one-step process to develop the film and it provides accurate color rendition in the final image. It has a lower exposure latitude than negative film and is generally more expensive.
Instant Film	The film and processing are all provided in the one package. It is quick and convenient but is lacking in quality compared to negative or slide film.
Film Speed	The ASA (American Standards Association) or ISO (International Standards Organization) number indicates the speed of the film. As a starting point, ASA 100, 200 or 400 are acceptable for forensic photography.
Color Balance	"Daylight" films are manufactured to perform best in daylight or with electronic flash. "Tungsten films" produce best results in the red/yellow light from incandescent light sources.

All of the variables produced by these film characteristics will make a difference to the quality of the final image.

Processing by a secure, accredited laboratory with quality control is *mandatory.* Suffice to say forensic work should never be sent to the local photography shop. It is also important to test different films and processing laboratories prior to photographing an important case.

CONSIDERATIONS

Once the photographic equipment has been purchased and tested, there are then other considerations to be taken into account. In time, these will become second nature but in the beginning they should be actively decided upon with each photograph that is taken:

- Lighting
- Exposure and color
- Focus and depth of field
- Perspective
- Case identification and scale
- Background
- Orientation
- Cropping

LIGHTING

Check and recheck that the flash is turned on and that it is set to the correct settings. Direct the flash head at an angle to the subject so the reflection will bounce off at an angle. If the flash is parallel to the subject, the light will bounce directly back into the camera causing a reflection. This is known as a specular highlight and can obscure important information. If you have an off-camera flash with a directional head, this can be avoided. Of course, this then introduces a problem with shadows falling on the subject, which must also be taken into account. Just as one checks where the sun is when taking photographs outdoors, the photographer must also check the angle of the light source falling on the subject indoors.

Exposure

Ensure that the film and flash have been tested in a variety of conditions and can produce consistently accurate exposures. Extra reading will be needed to deal with situations where there is a very dark or very light area in the image, e.g. a burnt body. If the exposure is incorrect, the color and detail of the resultant image will be affected.

Focus and depth of field

The point of interest must be identified and the camera lens positioned parallel to this point of interest. Depth of field can be a big problem for forensic photographers, especially with close-up images.

Again, the best advice is to be parallel to the point of interest. In most instances, the maximum depth of field is obtained by focusing one-third inside the area of interest. If the injury itself is on two or more planes — for example, if an object is embedded in the skin, then several images focusing on the different planes of the point of interest should be taken.

PERSPECTIVE

Care must be taken when selecting a lens to ensure that any distortion of the perspective is minimized. As a rule of thumb, the camera should be at least ten subject diameters away (Williams, 1984), so a ladder and a large working area are vital to provide enough working distance between the lens and the subject. One of the biggest mistakes in forensic photography is to leave a wide-angle lens on the camera while moving in towards the body to take close-up photographs. The correct procedure is to change lenses to a longer focal length remaining about the same distance from the subject. Another common mistake is to photograph a subject at an oblique angle as this, too, will distort the perspective (see "Orientation").

CASE IDENTIFICATION AND SCALE

Every image should be taken twice — with and without a scale. The primary purpose of the scale is to have a measurement device in the photograph. Some scales also have a section where the case number can be written, which is useful for case identification. As the scale may cover important information, every image must also be taken without the scale. Both images should be exactly the same (with the only variable being the scale). It is extremely important that the scale is placed at the same level as the plane of focus though this can take some ingenuity at times. For example, a small piece of plasticine may be moulded to hold the scale in the correct position as long as it isn't visible in the image.

BACKGROUND

Ensuring the background is clear of any distracting material will dramatically improve the resultant forensic images. Stainless steel surfaces play havoc with camera metering systems and result in specular highlights and incorrect exposure. Coating mortuary trolleys (or tables) with a gray or blue laminate (as close to 18% gray as possible) for photography purposes has proven very successful in overcoming these problems. Other techniques involve coating thin wooden boards with the laminate as described and sliding these underneath the part of the body to be photographed. The same boards can also be used as surfaces on which to photograph body organs, and to hold behind the body to avoid getting the rest of the mortuary in the background. *Always ensure all backgrounds are clean.*

ORIENTATION

The film plane should be parallel to the plane of focus and the framing of the photograph should be in line with either the horizontal or vertical plane of the body. These systematic methods ensure a true perspective and ensure easy identification of the location on the body that the image was taken. Try to avoid taking images at random angles. If it is absolutely necessary, then include standardized shots as well. Include anatomical markers and ensure all images are matched with another wider view to identify the location of the image. As an example, consider the photography of a distant shotgun injury where there are several similar entrance wounds: a good set of forensic images should contain overall documentation (including anatomical markers) followed by groups of injuries (with and without scale) and finally, close-up documentation. In cases where the groups of injuries are similar, orientation will be assisted by using the scale or a label to denote each injury A, B, C, etc.

CROPPING

Cropping ensures that no more and no less than what is absolutely necessary is included in each image. Avoid including any extra material that is irrelevant or distracting or just empty space. Be careful not to crop too tightly around bruises where the edges can be difficult to define. If using negative film, take into account that up to 10% of the image may be cropped during the printing process.

PHOTOGRAPHING THE GUNSHOT INJURY

If the camera kit is reliable and has been tested thoroughly — and if the above points have been taken into consideration — the photographer is now ready to take some photographs. Having a clear plan of action is very important. If the photographs are being taken for a third party, try to have the person close by to check and confirm exactly what information is required to be documented.

Remember, forensic photography is all about being accurate and methodical in the approach. To assist the photographer in this, there are some common terms that are used to describe the various methods of photographing a body. These should be familiar to the photographer.

- *Homicide work up*: describes a set of photographs that forms the bare minimum of photographic evidence when investigating a suspicious or violent death. Once the body has been admitted to the mortuary — and prior to stripping and washing — the body should be photographed front and back. The front and back of the hands should also be photographed. Any bloodstains on the clothing or skin should be documented as well as any damage to clothing. Any visible injuries should be photographed at this time. All these photographs are repeated after the body has been stripped and washed. Every injury must be photographed with and without a scale, followed by any other photographs as directed by the pathologist.

- *Overall documentation*: refers to the documentation of the body as a record of its condition upon admission to the mortuary. As a guide, most cases will require overall documentation; however, *all* homicide and suspicious cases must be fully documented. A proven method is to stand on a ladder and photograph the body in three sections from directly above. Each image should overlap the previous image so there are no portions left undocumented. This process is repeated once the body has been stripped and washed. While it is possible to photograph the entire body with one image using a wide-angle lens, it is difficult to get directly over the top of the body, and the image tends to be taken at a slight angle — which is not desirable.
- *Orientational view:* describes photographs that concentrate on a certain area (e.g. the head) in order to provide more detail. Orientation images must include anatomical markers or be accompanied by overlapping images so the viewer knows where on the body the images were taken. These images are typically taken with a standard lens. A typical series for the head would include the head and neck area from above and from each side.
- *Close-up shots:* are images that are always accompanied by overall and orientation images. It is vital to be methodical when taking close-up shots to ensure anatomical landmark photographs are also taken to identify the location of the injury on the body. Obviously the type of gunshot injury and its location on the body will dictate the type of images that are taken.

A STEP-BY-STEP GUIDE

Once the autopsy has begun the photographer should be close by to document any part of the process as instructed.

1. Overall documentation as body is admitted to mortuary.
2. Orientation photographs of the gunshot injury(s) before the body is washed.
3. Photography of any blood stained or torn clothing before the body is stripped.
4. *Before* the body is stripped and washed, *check* with the pathologist to be sure that all the required images have been taken.
5. Photograph any paperwork found in the pockets of clothing as indicated by the pathologist. As each piece of clothing is removed it should be photographed front and back, with additional close-ups of any important areas such as bloodstains or torn fabric. It is best to lay the clothes out on a *clean* background (such as a blue board) for documentation. Photograph each item with and without scale.
6. Overall, orientational and close-up photographs of the body are repeated once the clothes have been removed and the body has been washed. More injuries may be visible at this stage and these should be carefully documented ensuring orientation and anatomical markers are considered. Features that help with identification of the individual such as tattoos, facial features, birthmarks, and scars are also documented at this stage.
7. Sometimes the lack of injuries can be important and the pathologist should be consulted along the way to check that all the necessary photographs are taken.
8. If an area of skin needs to be shaved in order to examine it more closely, then it should be documented before and after shaving as important information can disappear with the process.
9. Photograph any guns or ammunition that are available. Photographs of the gun barrel with and without the scale can be very useful in contact gunshot injuries. A gross specimen set-up (see box) is also useful to photograph guns and ammunition.
10. In addition to the above points, the pathologist may also request images showing damage to internal structures or the path of a projectile through an organ. As with external photographs, orientation is just as important with internal photographs. If the organ from the body is removed it is best to use a gross specimen set up for documentation. If a separate set-up is not available then a clean blue or grey board will suffice.

DIGITAL IMAGING

The affordability of reasonably high resolution, compact digital cameras means that the argument of the digital versus traditional format camera is one the forensic photographer needs to explore when deciding on equipment. Although advances have been made in digital photography that may indeed satisfy the requirements for some forensic documentation, the resolution and image detail capabilities of a 35 mm SLR kit remain far superior to digital cameras (which are aimed for the domestic user). All that said, high-end digital cameras are a consideration if the budget will allow; however, it is important to remember that susceptibility to tampering is the main issue that surrounds the use of digital imaging in the forensic arena. When images are provided to the court, the photographer must be able to account for each image and take responsibility for the continuity of the image from its original to its final state. Each department involved in a case should have a strict protocol overseeing the continuity of evidence — whether the methods used are digital or traditional.

Regardless of whether the camera is digital or traditional, the photographer still needs to have a good grasp of the photography principles discussed in this chapter. Digital imaging should be viewed as just another tool available to the forensic photographer.

CONCLUSION

The purpose of each forensic photograph is to assist the viewer by clarifying aspects of the forensic pathology examination. As a result, the most important principle of forensic photography is a systematic and accurate approach. This chapter has merely scratched the surface to cover the main considerations; the author urges extra reading and experimentation with forensic photography as the ability to document an important case without worrying about the quality of the photographs is well worth the effort. Finally, remember that many a pathologist has been grateful for the methodical approach of a good photographer

FIGURE 26.1 35mm SLR camera with a motor winder and electronic flash.

FIGURE 26.3 55 mm lens (standard lens) Note that "micro-nikkor" indicates that the lens has closeup capabilities.

FIGURE 26.2 35 mm lens (wide angle).

FIGURE 26.4 105 mm lens. Also a specialized macro or micro lens with closeup capabilities.

FIGURE 26.5 Demonstrates capability of 105 mm lens.

FIGURE 26.6 Forensic photographs should always include photographs both with and without a scale.

FIGURE 26.8 By using the ladder the photographer is in a position to hold the camera parallel to the plane of focus.

FIGURE 26.7 The location of the injury (see previous photograph) is clearly identified with an orientation photograph. The location of the injury would be very difficult to identify without the orientation view.

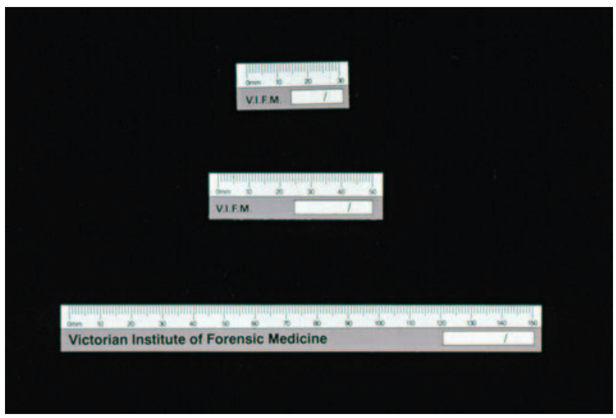
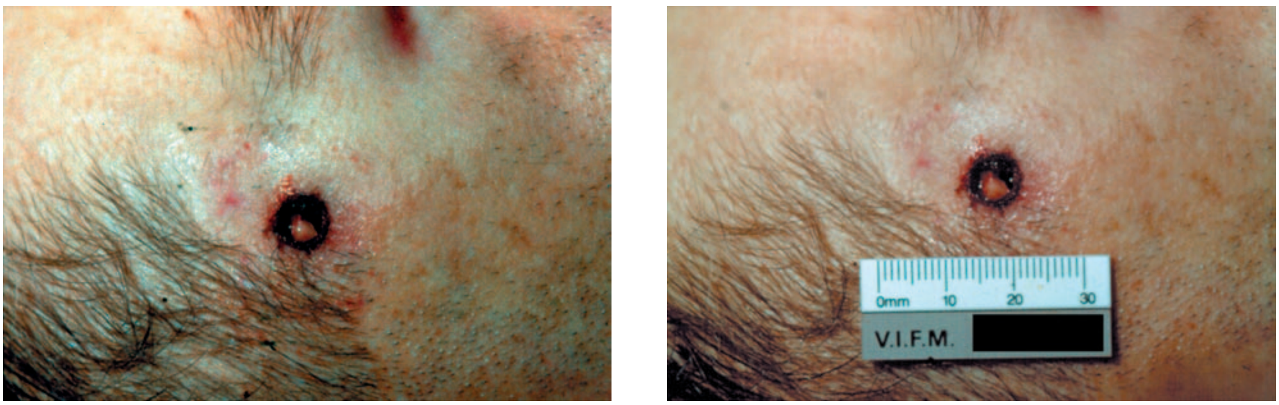


FIGURE 26.9 A variety of accurate scales with adhesive backs is very useful in forensic photography.

FIGURE 26.10 Demonstrates orientation view.

FIGURE 26.11 Orientation view after the wound is cleaned. Note that the magnification and cropping in a series should remain consistent. The only thing that has changed is that the area has been washed



A B

FIGURE 26.12A, B Closeup of the entrance wound. Note the cropping; the tip of the eye and eyebrow are visible to help orientate the viewer. Again the injury is photographed with and without the scale.

FIGURE 26.13 Demonstrates orientation view.

FIGURE 26.14 Area shaved and cleaned. Note the clean non-distracting background.

FIGURE 26.15 Closeup of injury.

FIGURE 26.16 Closeup with scale.

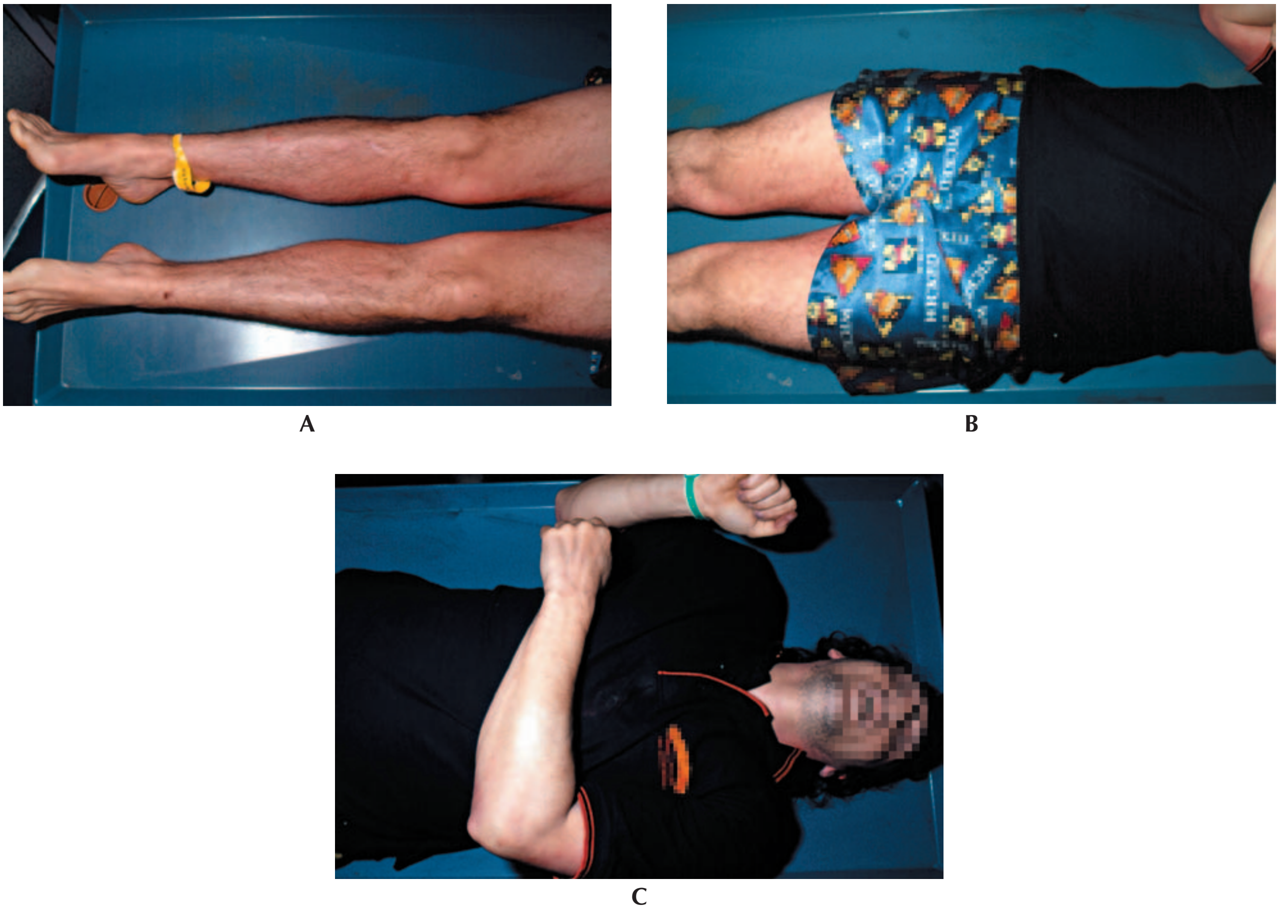


FIGURE 26.17A, B, C Overall series demonstrating the technique of photographing the body in three sections from directly above. Note there is considerable overlay of the previous photograph.

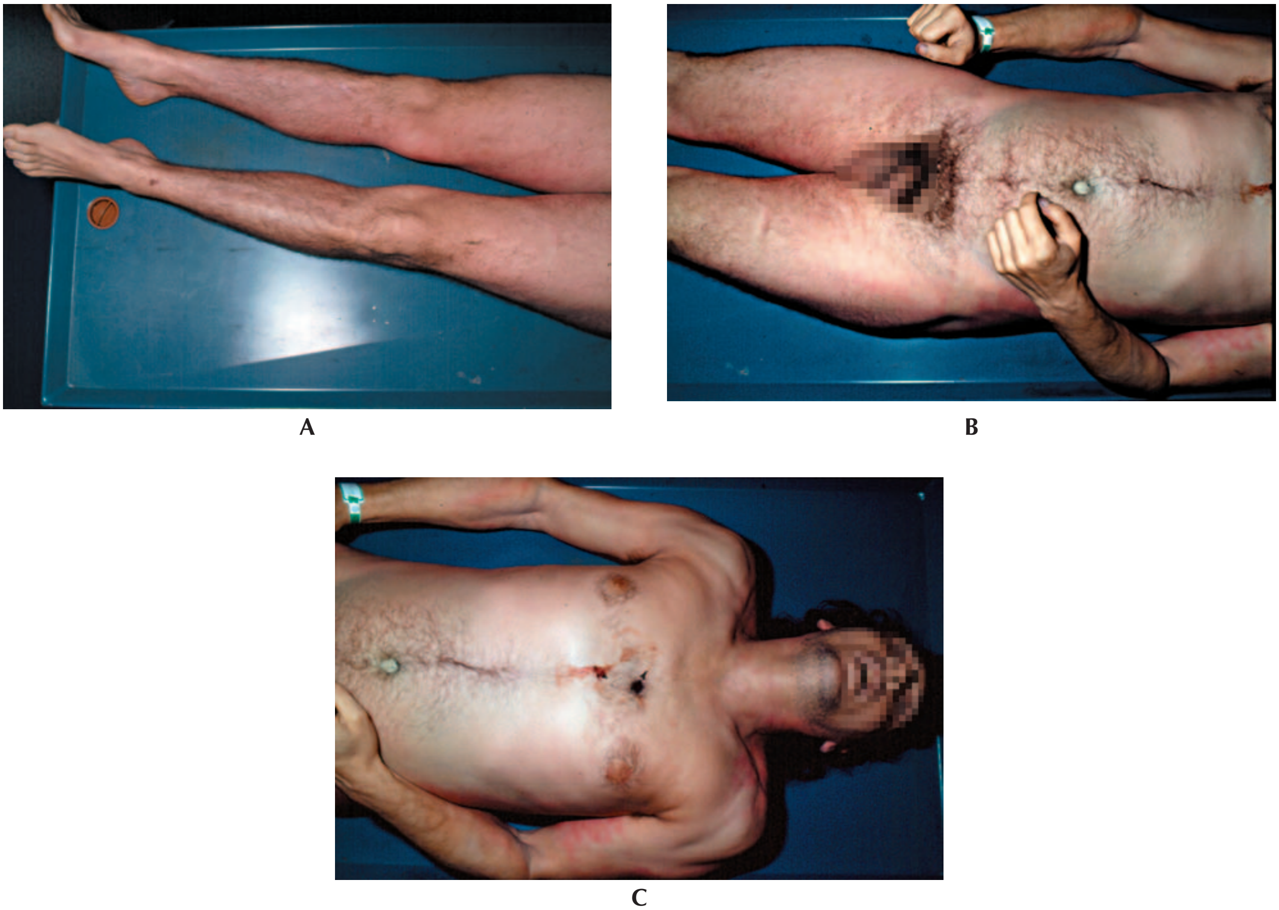


FIGURE 26.18A, B, C The previous series is repeated once the clothes have been removed.

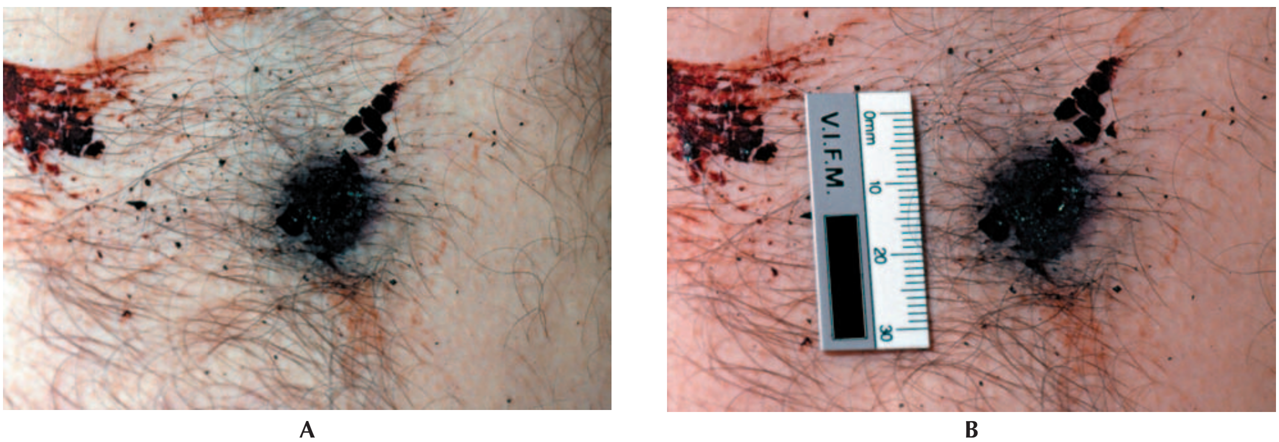


FIGURE 26.19A, B Closeup of the injury to chest prior to being cleaned, with and without a scale.

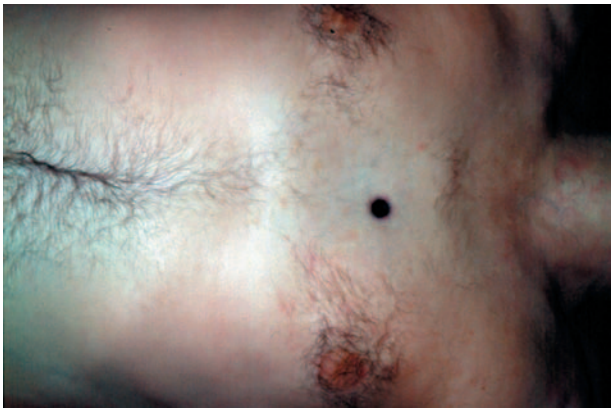
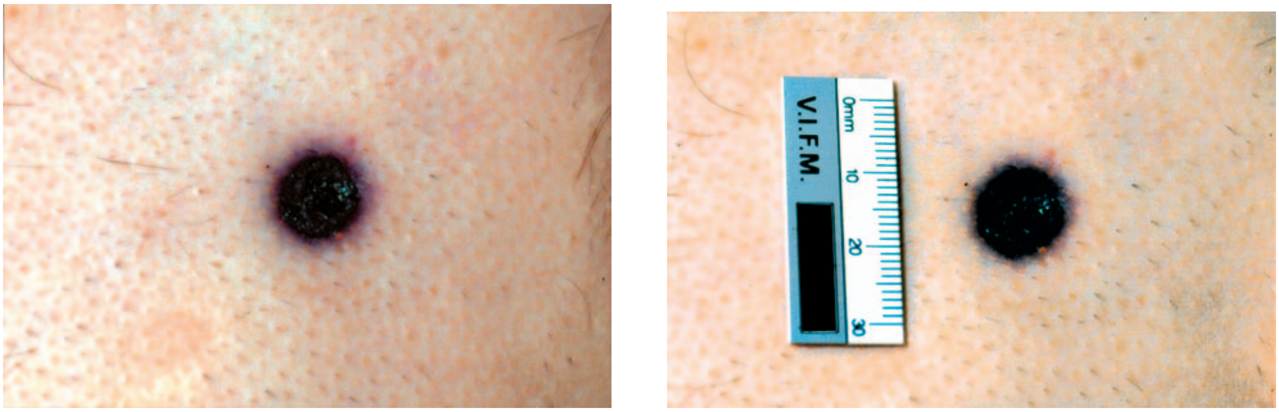


FIGURE 26.20 Orientation photograph (after area has been cleaned and shaved) shows the injury in respect to surrounding anatomical features.



A B

FIGURE 26.21A, B Closeup of injury to chest after area is cleaned and shaved. Each step of the process is meticulously documented.

A B

FIGURE 26.22A, B Clothes are photographed on a clean, non-distracting background with and without a scale.

27 Forensic Entomology as Applied to Gunshot Injury

The forensic entomologist may assist greatly in the interpretation of bullet wounds that have been modified by insect activity. In addition, the entomologist may also be of great assistance in the determination of post mortem interval (PMI).

The passage of a projectile into the body creates a defect and an immediate access point for the deposition of fly eggs. In most cases, blood will escape. In other instances, deeper tissues such as fat, muscle, and occasionally, viscera will be exposed. This is, of course, largely dependent on the size of the entry or exit point, which is in turn dependent on caliber, velocity, and frequently, muzzle distance. The blast effect of the 12 gauge shotgun obviously creates a wider access for egg deposition than the small defect produced by the .22 caliber projectile.

In most cases, there will be a serosanguinous ooze from the wound. Blood and other protein rich fluids are highly attractive to gravid female flies and thus colonization of wounds is often rapid. Eggs, or for some species, live larvae, are deposited on skin, within natural orifices and obviously, wound sites. The eggs mature to eventually form larvae (maggots), which progress through three phases of morphological change — termed *instars.*

At the end of the third instar, the larvae cease feeding and migrate from the body to bury themselves in soil, or if indoors, suitable environments such as crevices or beneath carpets. This "wandering" stage is called the prepupae. The larvae eventually transform into pupae. At a later time, the mature fly will emerge, leaving behind the dry pupal husk — the puparium. Depending on the species and environmental temperature, a complete blow fly cycle may take as little as nine days to well over a month.

Maggots (larvae) excrete protolytic enzymes directly onto flesh as they feed. These enzymes will rapidly soften and literally erode the edges of the gunshot wound. This effect is often not fully appreciated by the forensic pathologist. It is potentially possible that the features that typify a gunshot entry wound, such as the abrasion rim, sooting and thermal effect, may be altered by the digestive effects of these protolytic enzymes. In this instance, the histological examination of bullet wounds may help to resolve the problem of ranging.

A further complication is the fact that maggots may burrow into or out of the skin at sites of active feeding and may readily create defects that closely resemble that of gunshot injury. This has, in at least one case, caused confusion when small perforations were misinterpreted as shotgun pellet entry wounds. The caveat here is — always, but always — X-ray a suspected victim of gunshot. This is especially necessary in the decomposed body. In these cases, the maggots tend to burrow to a depth of several centimeters.

At later stages of decomposition, if the body mummifies, other species may also burrow into skin and subcutaneous tissues. In a worst case scenario, the action of insects may completely obliterate an otherwise obvious bullet entry wound.

Who should perform this highly specialised study?

It goes without saying that the study of entomology, especially in its forensic application, is not for the part time player or for the forensic pathologist with more than a passing interest in the subject. The study must be undertaken by a dedicated specialist with, at the very least, a degree in zoology and a special interest in forensic entomology.

It is becoming increasingly necessary to possess some form of postgraduate qualification in forensic entomology or to at least have extensive research experience with carrion insect ecology, taxonomy, and general biology. Most entomologists are affiliated with University departments or are employed in the field of agriculture. In the State of Victoria, we are indeed grateful for the employ of such a person. It cannot be too strongly stated that this specialized knowledge must be locally based. The biology of species found in the northern and tropical climes of our country differ markedly from those found in more southern latitudes and for those species that occur in both environments, seasonal activity times will also differ.

All species of fly particular to the area must be identified with great precision, and ideally, eggs and larvae grown to maturity in a controlled environment in a laboratory designed for that exact purpose.

In addition to the rationalization of the rather destructive effects of fly colonisation on the wound site, the determination of *post mortem interval* (PMI) is also possible. Accurate PMI determination is frequently touted as the Holy Grail of forensic pathology.

It is not the intent of this book to go into great detail on PMI determination. Many standard and specialised texts more than adequately deal with this complex subject. A brief outline is provided for completion however.

The PMI is that time elapsed from the instant of somatic death to the discovery of the body. This is a retrospective exercise in the vast majority of cases. Many techniques are available for this evaluation. These include the measurement of the core body temperature and the use of Henssge's nomogram, vitreous humour potassium levels, and other more obscure techniques such as post mortem mechanical and electrical excitation of skeletal muscle and pharmacological applications to the eye to provoke pupillary reactivity.

Many of these more obscure methodologies have a strong following in Northern Hemisphere countries, but are not widely accepted or practised as a routine. At the crime scene, a rough estimation of PMI can be made from determining the degree and distribution of rigor, the taking of the core temperature and occasionally from distribution and fixation of lividity (hypostasis). Experience will also provide a rough guide based on the apparent degree of frank decomposition.

PMI can be reasonably accurately estimated by establishing the minimum time since death either by calculating the age of the oldest insect larvae on the body or by analysing the species composition of insects. These estimations are based on data from previous studies of decomposing animal carcasses. Personal experience has shown that quite accurate estimation of PMI can be made from entomological studies, when all other modalities have given rough estimates only. It should be emphasized, however, that entomology gives an estimate only of the minimum PMI. Naturally, insects must have access to a body and ready access may be delayed for days or more, especially if the body is indoors, in a car boot or contained in some other way. For the most accurate PMI estimate, the body must be in an open environment. The ambient temperature also needs to be high enough to permit insect activity. The sooner after death the body is colonized, the more accurately the PMI estimation will match the actual PMI.

At the time of crime scene examination or body recovery, it behooves the forensic pathologist to seriously consider the employ of the specialist entomologist. Ideally, the entomologist and the pathologist should visit the scene together if sufficient information is given at the time by the informant that fly eggs and maggots are present on the body. A formalized collection protocol should be established for the collection of eggs, larvae, pupae, and mature insects. This can only be accomplished by developing good liaison with an enthusiastic entomologist who has a special interest in forensic applications. In addition, the entomologist can and should demonstrate collection techniques to mortuary staff, crime scene officers, and pathologists. As well as correct collection techniques, all information gained at the locus of the body discovery should be documented for further consideration.

Specialized data such as local weather patterns, rainfall, and temperature are also required to calculate the age of insect larvae feeding on the body.

The protocol used at the Victorian Institute of Forensic Medicine is highly recommended.

1. Preliminary Information
   - Features such as body position, number and nature of clothing items, an open or closed environment, stage of decomposition and position and type of immediately apparent injuries are recorded.
   - A map reference that will allow the entomologist to visit the scene and an accurate description of the scene habitat (forest, open, bush land) and sun exposure are recorded. The entomologist should also receive copies of scene photographs (with the body in situ) at a later date.
   - If the body is partially or completely interred, the depth of the soil is measured.

2. Maggot/Egg Collection
   - Eggs and maggots are collected from varying sites on the body.
   - At least 20 live maggots from each infestation on the body should be collected. A small piece of water moistened paper towel will prevent dehydration and death before the specimen can be transported to the laboratory.
   - The temperature of the maggot mass (if present) is recorded.
   - A further 20 maggots should be preserved for later examination in a process known as "fixing." Liaise with the entomologist as there are several fixing techniques. The placement of maggots in ethanol from the outset will result in both shrinkage and discoloration.

3. Adult Insect Collection
   - A net or sticky trap is used to capture any flying insects noted on or around the body.
   - Adult flies, beetles, or other adult insects should be placed in a small specimen jar containing 80% ethanol. The container should be labelled with date, time, and case number.
   - A collection of adult specimens is made from the body — this will include both live and dead insects.
   - Small forceps may be used on larger specimens and a fine paintbrush moistened with ethanol is a very suitable implement for the

collection of smaller and more delicate specimens.
- Separate collections should be made from areas such as the head, chest, and extremities. Specimens collected from specific wound areas should be appropriately labelled.
- *Never* mix live specimens of differing species in the same container; one species can potentially feed on another.

4. Soil Collection
   - Unemerged fly pupae (seen as small brown football shaped objects, generally 5-10 mm in length) should be collected live and placed in a small ventilated container and appropriately labelled.
   - At outdoor scenes, a search should be made for pupae in the soil.
   - Shallow trenches 7 cm deep and several meters long must be dug in various compass directions from the body. The soil can be sifted for prepupae and pupae.
   - A sample of leaf litter and 10 cc soil cores from under the body is also advised, as adults, larvae, and pupae of additional insect species can be found in these samples.

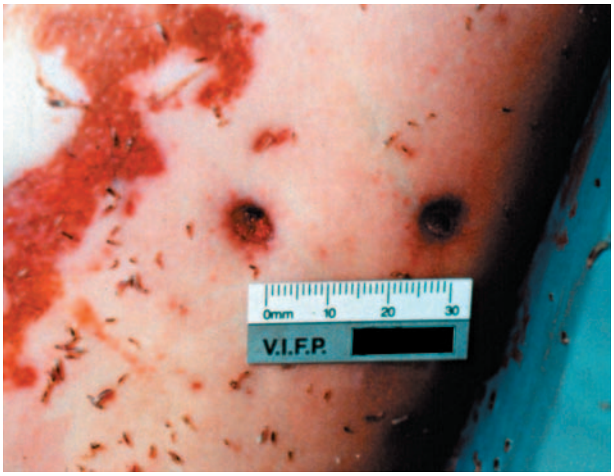


FIGURE 27.1 First instar larvae on the skin of a gunshot victim. The larger irregular areas of apparent abraded skin are due to the action of ant feeding activity

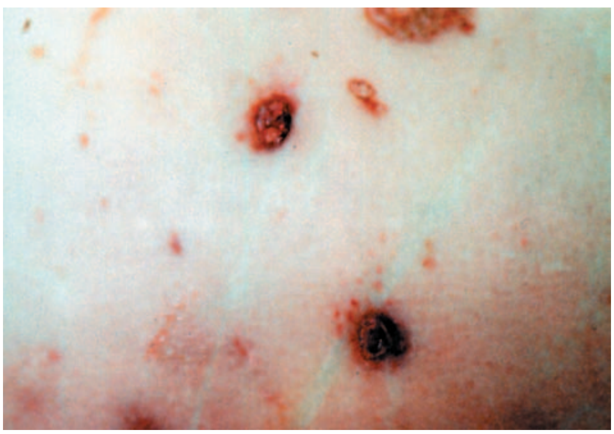


FIGURE 27.2 Once cleaned of maggots, the bullet wound edges may appear slightly mottled and irregular. Be aware of the digestive effects of proteolytic enzymes.

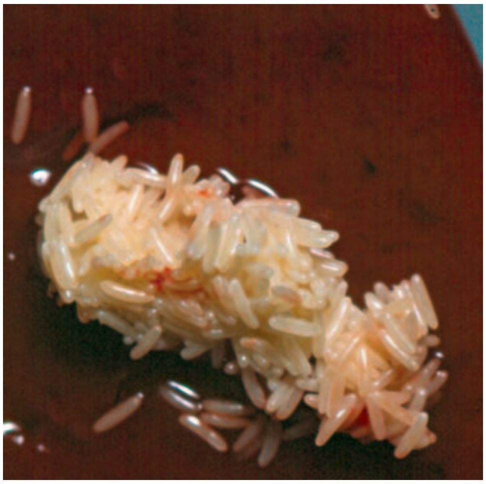


FIGURE 27.3 Eggs (2-3 mm).

FIGURE 27.4 Maggot mass.

FIGURE 27.5 Larvae.

FIGURE 27.6 Pupae.

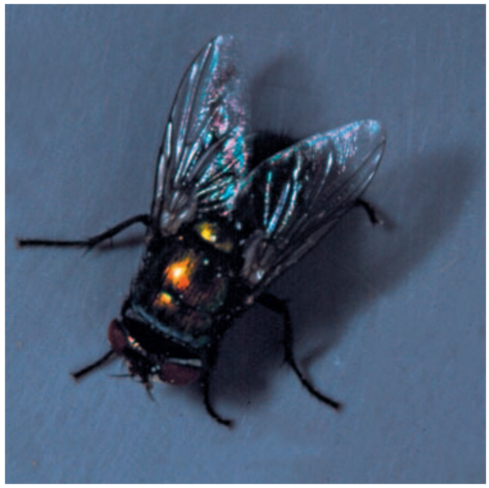


FIGURE 27.7 Mature fly.

THE LIFE CYCLE OF THE BLOWFLY — *LUCILIA CUPRINA*

28 Field Work in a Theater of War—Human Rights

In this, the final chapter of this book, I hope to address some of the problems that may face the visiting forensic specialist investigating atrocities in a theater of war. I base this on personal experience, having been privileged to be part of the British Forensic Team (2000) in Kosovo (under the auspices of the United Nations) and having had five "tours of duty" in East Timor, also under the UN banner. In recent years (2003–5), I have worked in the Solomon Islands investigating militia based killings.

Although one may feel confident with more or less "standard" gunshot homicides at home, it requires a somewhat different mindset when confronted with 50 or more body bags in a refrigerator, awaiting one's attention on immediate arrival in a strange land. It is best to approach each case as an individual event (i.e., a single homicide) and try not to be overwhelmed by the enormity of the project.

It is tempting to "cut corners" and rush a case through, but ultimately, it is a thorough report that will be pivotal in a successful war crimes prosecution. Therefore, do not drop your standards, keep good notes, and be prepared to "call the case" as you see it, even when faced with pressures from local authorities and agencies.

In many makeshift mortuaries in foreign lands, we often lack the facilities we are accustomed to, such as radiology, good sharp instruments, adequate lighting and ventilation, good water pressure, and an adequate supply of clean gowns and gloves. When dealing with particularly problematic cases, the pathologist may have to improvise, coerce and literally "beg, borrow, and steal." In most cases, the pathologist will not have the benefit of histology and toxicology; the incidence of "unascertained" will almost certainly rise in the absence of convincing trauma or natural disease.

The forensic pathologist may be engaged in a team of three (as in East Timor) or fifteen (as in Kosovo). The East Timor experience was invaluable to me. It honed my skills on the examination of skeletal remains (a rarity at home), physical anthropology and morphometry, exhumation technique, and the ability to be flexible enough to "get down and dirty" with the basic cleaning of bones covered in decomposing flesh and mud as well as cataloging of exhibits, photography, record keeping, and basic cleaning up procedures at the end of the day's work.

In Kosovo, the team of fifteen comprised one forensic pathologist (on rotation), at least two physical anthropologists, one mortuary technician, one photographer, one radiographer, one scene of crime/exhibits officer on site at the mortuary, and a miscellany of personnel acting as exhumation technicians, record keepers, and team coordinators/administrators. This was a comfortable situation in comparison to East Timor, but the essentials of the work and expected goals were the same.

I regard work of this nature to be of the greatest importance and feel that all fully qualified forensic pathologists have a moral duty to participate in such work should the opportunity arise.

THE EAST TIMOR EXPERIENCE

On the 30th of August 1999, the people of East Timor were asked to vote on their future — a referendum to decide on independence or autonomy under Indonesian rule. On that day, 98.6% of registered voters went to the polls. The vast majority (78%) voted for independence. Killings and intimidations had occurred in the weeks leading up to the referendum, mainly perpetrated by Indonesian backed Militia groups in West Timor. Widespread killings occurred soon after the announcement of independence; the capital, towns, and villages were destroyed and many people were dispossessed. The actual number of murder victims will never be known, but most agree that many hundreds died in the weeks after the referendum.

Although some cursory graveside examinations had been performed by nonspecialist personnel soon after the arrival of International Force East Timor (INTERFET) in October, I had the privilege of being the first forensic pathologist to undertake formal autopsy examinations of the first exhumed remains. These examinations commenced in mid February 2000, during the "wet" or monsoon season. The temperature was generally in the low 30s (Centigrade) with humidity of greater than 90%. The examinations were conducted in a makeshift mortuary, a large room that was part of the Agricultural College of Dili, Komoro. A mobile refrigerated container held the body bags, victims exhumed earlier that year in the Oecussi enclave. Dental examinations had already been performed and photographs taken by a forensic odontologist.

All bodies were retained in standard body bags. The contents comprised the skeletal remnants, items of clothing, evidential material, and the immediate soil that surrounded the body.

The locus of disposal varied enormously. I was informed by investigators that some burials had occurred in shallow ground which had been largely washed away by the heavy monsoon rains. Many other bodies were left above ground and were rapidly predated by the local fauna. The majority of the bodies examined were fully skeletonized; some were in an advanced state of decomposition and others were represented as isolated bone elements.

The investigation team consisted of myself as forensic pathologist, a physical anthropologist and an INTERFET soldier acting as scene of crimes/exhibits officer. The following stages of examination were performed, each full examination taking approximately two to three hours.

1. The body bag was opened and the contents photographed in situ.
2. The forensic pathologist identified all bones and placed these aside for washing and cleaning — ideally the pathologist should perform this task.

It was not uncommon for ligatures to surround the long bones of the extremities. All anatomical relationships with the ligatures need to be preserved and all evidential items photographed in situ.

3. All items of clothing were carefully examined in situ for obvious defects and are then removed for washing, drying, and tagging.
4. All residual soil is scanned for metallic objects by a handheld metal detector.
5. All soil was diluted and then put through a 1/4 inch mesh sieve.

This step was perhaps the most time consuming, as the soil was of a sticky clay type and the water pressure was negligible.

6. All bones, having been cleaned of debris, were placed on a post mortem table in anatomical position, photographed, and logged in a bone inventory by the anthropologist.
7. Height, age, and gender assessment were performed by the anthropologist using standard techniques.
8. All bones were then examined by both a forensic pathologist and an anthropologist in tandem for evidential wound defects such as may be seen after blunt force, incised injury, or gunshot.
9. All bones so identified were put aside and photographed with and without scale as a permanent record.
10. A complete record was generated on a proforma by the pathologist, listing all injuries, bullet trajectories, natural disease, and distinguishing features and a final comment made regarding the causation and mechanism of death. All reports were signed and dated on completion. A photocopy was retained by the pathologist for personal use.
11. All evidential material, clothing, and personal items were photographed and catalogued by the scene of crime officer.
12. All items of evidential material, and all skeletal elements demonstrating trauma, were stored in a secured environment.
13. The cleaned nontraumatised bones were packaged and returned to the village.

The majority of the victims of atrocities examined in East Timor met their deaths by multiple blows from large jungle knives called machetes, known locally as *katanas*. A minority demonstrated the obvious hallmarks of gunshot trauma. The fully skeletonized bodies exhibited no more or less than internal and external beveling and focal bone shattering. With the aid of body maps, the trajectory of the bullets could be determined. In bodies showing advanced decomposition, this task was not so easy. It was required, on occasion, to fully "skeletonize" the body to disclose the telltale signs of trauma.

Due to the high temperatures and humidity, and relative acidity of the soils, many of the projectiles had oxidized and degraded. It was not uncommon to see fine granules of bluish-green material representing the oxidized bullet jacketing and the projectile itself to be seen as friable grey material which could not be picked up by the metal detector. The rare intact projectile was encountered, however.

All 51 body bags were examined after 10 days of continual work under adverse conditions. The net result was a representation of 49 individuals, with most having a "reasonable cause of death" assigned.

As mentioned, the majority of victims died from incised injury with skeletal trauma in keeping with multiple blows from a heavy jungle knife. Many were decapitated. Many more showed evidence of torture and mutilation. Some met their end after suffering blunt trauma to the head. Most of the gunshot victims died from the effects of conventional projectiles.

One case, however, demonstrated to me that local knowledge is invaluable in interpreting injury patterns. The East Timorese can produce home made firearms, known locally as *ratakans*. The *ratakan* is essentially a primitive scatter gun that can fire small projectiles comprising gravel, metal fragments, and glass. Understandably, defined metallic projectiles such as lead or steel shot are a rare find in these cases. Needless to say, many of these projectiles are not identified by the metal detector. In at least one case, an immediate cause of death was one of multiple stab injuries. Close examination of the posterior surface of a T-shirt, however, showed multiple small perforations in keeping with a shotgun discharge. Bony injury was not identified after careful examination. Without local knowledge, interpretation of clothing trauma of this description would be problematic.

Anecdotally, a case was related to me regarding a man who had been shot in the chest with such a weapon. His heart contained multiple fragments of gravel.

My later tours of East Timor included some "fresh" cases of gun fire and blunt trauma as well as participation in multiple exhumations from the highland territories. After full examination of all skeletal elements, most bullet trajectories could be determined with reasonable accuracy. The use of whole body map and skeletal charts are invaluable for documentation as well as synthesizing thoughts during the examination. No radiology was available during my first term. After fostering good relationships with the local army base hospital nearby, radiological facilities were available to me during my second and third tours. I also found that the use of long blunt probes helped enormously in determining accurate passage of projectiles through the body.

One of the great pleasures of such work is the passage of information to local villagers in medical training. We were privileged to have up to three local East Timorese assistants during our second and third tours. All participated in the cleaning process of the skeletal elements and in reconstruction after formal post mortem examination of intact bodies. Two of our assistants had some rudimentary medical and nursing training. Tutorials in basic anatomy and pathology were greatly appreciated and eagerly sought.

It was heartening to think that in some small way, we had assisted in their medical training and that their expertise later would be of great benefit to their community — a population of quiet gentle people at the crossroads of their future.

KOSOVO

As mentioned in my preamble, the British Forensic Team (BFT) consisted of one forensic pathologist and 14 additional personnel, each with well defined duties. The BFT is a purpose–built unit and has staff with great expertise gleaned from work in Bosnia and its environs. The forensic facility was a conventional post mortem room in the anatomical pathology department of the University of Pristina.

The BFT had the use of a single large room with two stainless steel autopsy tables, running water with good pressure, and nearby changing facilities. All bodies were kept in a dedicated and recently installed mortuary refrigerator in the hospital basement. Key personnel included a radiographer, two physical anthropologists, a photographer, and a scene of crime/exhibits officer.

The use of a portable image intensifier made identification and localization of projectiles and shrapnel an easy task. The exhumation site was a conventional Albanian cemetery on the outskirts of Pristina.

Clandestine mass graves were scattered between conventional grave sites.

A large earth mover was used to remove top soil. The first bodies began to appear at a depth of approximately five feet. By contrast to the bodies examined in East Timor, most here were intact and showed varying degrees of decomposition. There were no fully skeletonized bodies to examine during my rotation. Many were clothed, others were naked.

It was not uncommon for bodies to be piled one on top of the other, reminiscent of the scenes of the death camps in Nazi Germany. Immediate signs of trauma were identified in a minority of cases on site. After examination it was determined that the vast majority had been shot multiple times with either 7.62 or 9 mm rounds. All bodies were intact but ranged widely in their degrees of decomposition.

In general terms, the procedure was essentially the same as performed in East Timor.

1. All bodies were photographed with their accession number *in situ* at the grave site and again in an opened body bag beside the exhumation pit.
2. The bodies were then transferred under guard to the mortuary facility, logged in and secured in the basement refrigerator.
3. Each body was transferred to the post mortem room for further examination.
4. Overall photography of the body was performed in the opened body bag with accession number.
5. Any immediate injuries were photographed with and without a scale *in situ*.
6. A total body scan was performed under image intensification — all projectiles and shrapnel were mapped on a body chart for later reference.
7. A detailed external examination was then performed by the forensic pathologist.
8. A description of all clothing was made and all details logged on a proforma.
9. The anthropologist performed an estimation of gender, height, and age using standard technique.
10. An examination was made of all clothing items with demonstration of any defects such as stab wounds or bullet holes.
11. Identification of all body trauma sites with a full description in relation to anatomical landmarks, dimension, and external features.
12. All injury sites were photographed with and without scale.

13. A formal internal dissection was performed — the degree of examination was largely determined by the state of decomposition.
14. If the body was in an advanced state of decomposition (i.e., in a semiliquid state), then full skeletonization was performed and all bony elements examined as in East Timor. If the body was intact and relatively well preserved, a formal autopsy dissection was performed as a routine.
15. All projectiles and shrapnel removed under X-ray control.
16. All projectiles and shrapnel were handed to the scene of crime officer and logged in an inventory.
17. The body was reconstructed if appropriate, bagged and returned to the mortuary refrigerator.
18. All clothing was then washed, dried, photographed, logged, and stored in a secured environment.
19. Femoral head and dental pulp tissue was put aside for DNA assessment at a later date.
20. A formal report was completed after each autopsy examination on a standard UN generated proforma, with again, a final comment as to the cause and mechanism of death.

In East Timor, the pathological "range of fire" estimation was virtually impossible due to advanced decomposition. In Kosovo, only a minority of cases could be classified as anything other than distant range. Only one case could be confidently classified as "contact range" during my time as examining pathologist.

The determination of projectile trajectory (entry to exit), number of rounds fired and caliber was considered the most vital data for prosecution purposes. Victim identification was later sought by the viewing of personal effects, clothing, and I.D. cards by potential next-of-kin. These "viewing sessions" were performed en masse at large public venues and all information collated by trained liaison officers.

It is suggested that a rotation of three to four weeks is sufficient for the visiting forensic pathologist. Again, this type of work is highly recommended, at least once. All reports need to be of the highest standard and open to scrutiny to any agencies involved in both prosecution and defense. Always tackle one case at a time and try not to be overwhelmed by the enormity of the project even if you know that a further 20 bodies were exhumed that day and there were still five to go at the close of proceedings.

East Timor

FIGURE 28.1 A view of the rear of the makeshift mortuary complex. The grounds of the once impressive Agricultural College of Dili have been largely reclaimed by the lush tropical vegetation.

FIGURE 28.2 The autopsy room prior to the first post mortem examination. The floor is of highly polished white tile (slippery when wet). The stainless steel trays sit upon frail wooden trestles. Water pressure and ventilation are marginal.

FIGURE 28.3 A view of the room in full use. A side table is set up for the performance of a full autopsy on a "fresh case."

FIGURE 28.5 Typical bullet wounds to the chest from high velocity projectiles. 7.62 caliber.

FIGURE 28.4 The author performing an autopsy on an intact victim of gunshot. Tutorials in basic anatomy and pathology were always greatly appreciated by our local East Timorese assistants.

FIGURE 28.6 The use of long blunt probes were of great assistance in trajectory determination.

FIGURE 28.7 An exhumation of two brothers killed and dumped by the militia in a ravine in the East Timor Highlands. Their grieving mother and local villagers gather to watch.

FIGURE 28.8 The contents of a typical body bag from the Oecussi enclave. The bag contains skeletal elements, clothing, evidential material, and adherent soil. The skulls had been cleaned and a full dental examination performed prior to my arrival.

FIGURE 28.9 The author separating skeletal elements from soil. The soil is then scanned by a metal detector and later put through a sieve to retrieve small bones, teeth, and evidential material.

FIGURE 28.10 All bones, having been cleaned and dried, are laid out in anatomical position. All elements are logged in a standard bone inventory. A careful examination is then performed by both forensic pathologist and anthropologist and all traumatized elements are then set aside. Evidential material is then photographed and documented.

FIGURE 28.11 A particularly problematic case. An extensively decomposed adult male allegedly shot many times with an automatic rifle. At least four well defined defects are identified in the upper right chest. An intact 7.62 caliber projectile was located within the deep pelvis. Radiological assistance not available.

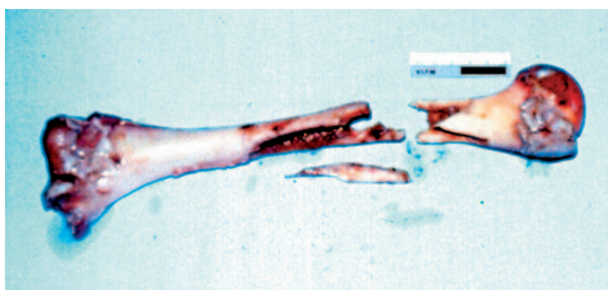


FIGURE 28.12 After skeletonization, the typical trauma pattern to long bones from a high velocity projectile is revealed.

FIGURE 28.13 A typical entry wound to the mid occipital region. Note radial fractures. The bullet calibre was unknown but was likely to be a 9 mm projectile.

FIGURE 28.14 A further example of an entry wound to the occiput — a recurrent injury pattern.

FIGURE 28.15 The same skull viewed from the front. Note large extent of bone loss, exaggerated by soft tissue decay. The entry defect can be seen internally.

Kosovo

FIGURE 28.16 Removal of top soil from a proposed mass grave in a cemetery on the outskirts of Pristina, Kosovo.

FIGURE 28.17 The first of the bodies are uncovered. A naked male is lying in the prone position. In many cases, items of clothing were merely thrown over the body, others were fully and heavily clothed.

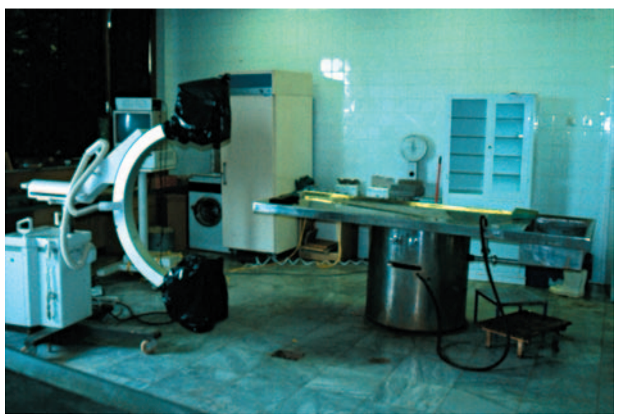
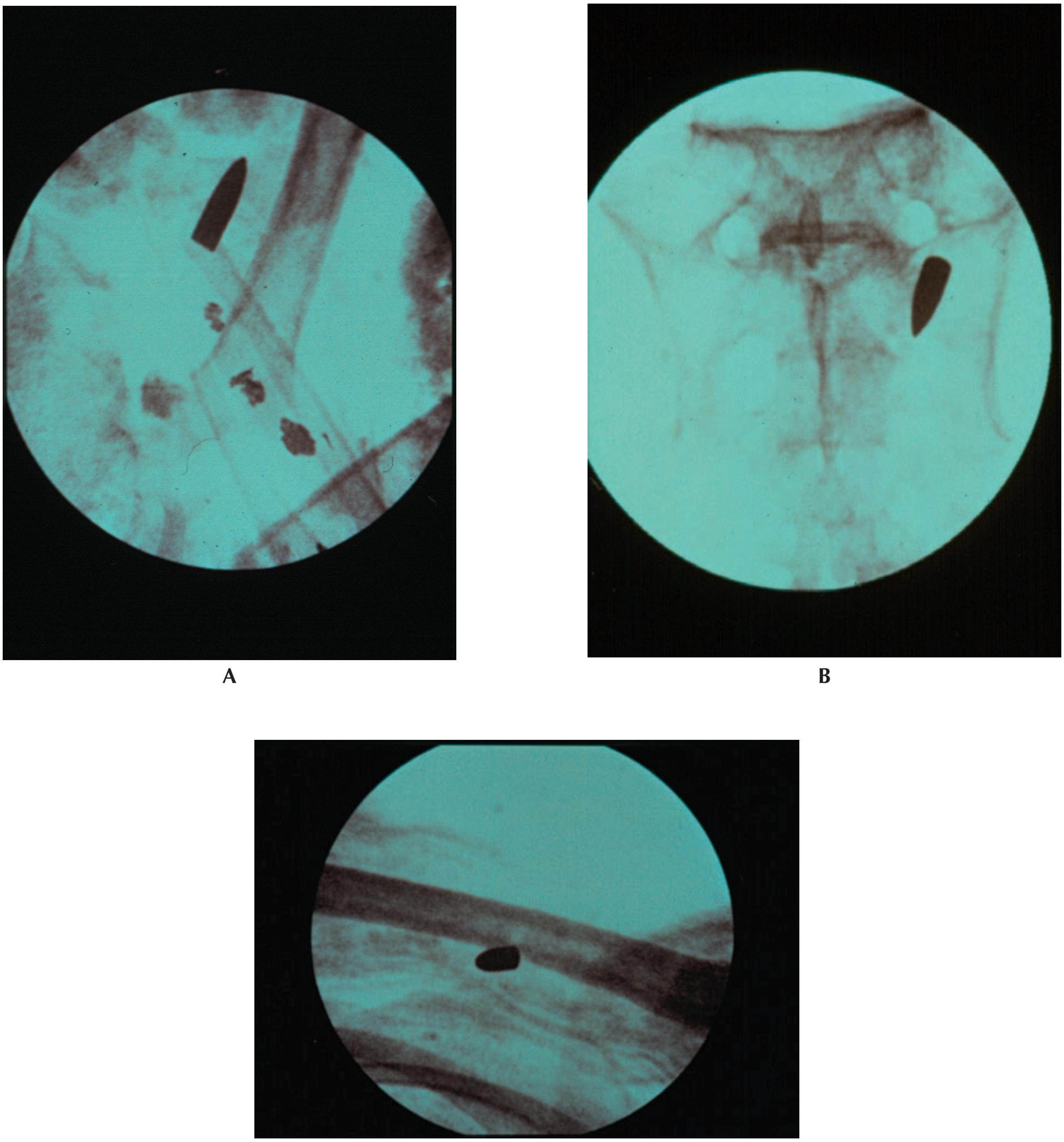


FIGURE 28.18 A view of the forensic post mortem room used by the BFT. Note stainless steel table and mobile image intensifier nearby.



A B C

FIGURE 28.19A, B, C A series of three printed radiographs obtained during scanning with the image intensifier. 7.62 caliber projectiles and shrapnel are noted adjacent to a long bone and within the sacrum, respectively. A 9 mm projectile was embedded in deep soft tissues in the upper extremity. A total body scan can be performed in around 10–15 minutes. Location and retrieval of projectiles and shrapnel is made easy with the aid of a radioopaque probe in "real time."

FIGURE 28.20 The author demonstrates a massive head injury from a high velocity projectile.

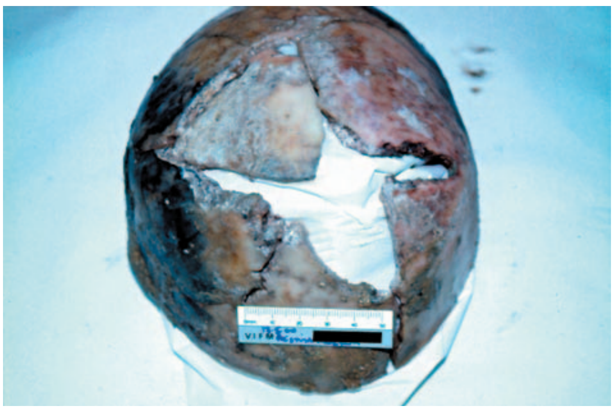


FIGURE 28.21 As above — a large graze type defect, the bullet passing from right to left. A large area of bone loss is seen with a zone of external beveling. This large tangential defect is in effect an exaggerated version of the key hole phenomenon.

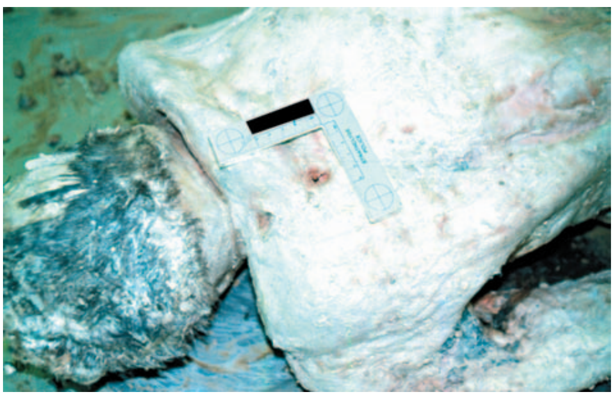


FIGURE 28.22 A well defined bullet hole is seen in the upper mid back of this victim. Not all bodies were so well preserved. This proved to be a through and through type gunshot injury. No projectile was recovered. Fine lead particulate material was identified on X-ray. The slightly everted edges are suggestive of an exit wound.

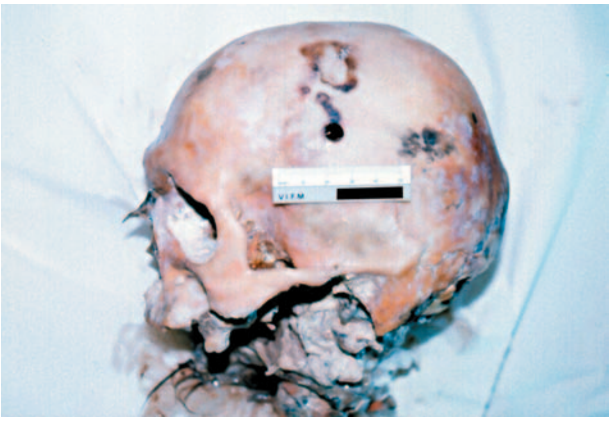


FIGURE 28.23 A well defined bullet entry wound to the left mid parietal area. There is no radial fracture.

FIGURE 28.24 As above, a classic exit wound through the contralateral aspect of the skull. Bone loss is seen above a semi-circular exit defect with external beveling.

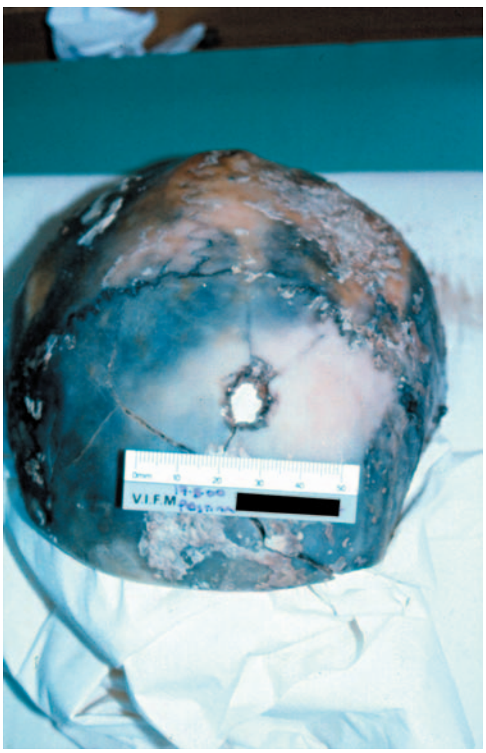


FIGURE 28.25 A further well defined exit wound to the frontal calvarium. Radial fractures are identified. An inferior radial fracture ceases abruptly with a transverse oriented fracture beneath the scale. Puppe's rule applies — the transverse fracture preceded the gunshot.

Part D

Appendix

Glossary

Abrasion rim A narrow circular zone of roughened (abraded) skin that surrounds the entry defect, caused by the scraping action of the (blunt) projectile as it penetrates the body.

Action The mechanism of the firearm that fires the cartridge, incorporating hammer, spring, trigger and firing pin. Any ejector mechanism is considered to be part of the gun's action.

Air powered weapon Any firearm that expels the projectile by means of rapidly expanding gas, not generated from combustion of propellants (i.e., compressed air or carbon dioxide).

Ammunition In common usage — bullets. A round of ammunition is a complete unit comprising cartridge case, primer, propellant, and projectile.

Anvil A component of the Boxer type primer. The anvil contains a percussion sensitive chemical that detonates causing the ignition and ultimately, combustion of the propellant.

Artefact A structure or phenomenon, not normally present in tissue, that may be formed after death (i.e., a hole produced by a migrating insect on a cadaver may readily resemble a bullet hole).

Ballistics The science of the passage of projectiles through the barrel of the gun, in flight and at the instant of impact. Ballistics is divided into internal (interior), external (exterior), and terminal (wound) ballistics respectively.

Beveling Beveling is divided into external and internal. Loss of a rim of bone as the projectile passes into or out of the skull (or other flat bone). Often seen as a well defined shallow conical defect at the point of exit.

Black powder Traditional gun powder, the original propellant thought to have been discovered by the Chinese. Gun powder consists of charcoal, sulfur, and potassium nitrate (saltpeter).

Blank A cartridge that contains a small amount of propellant but no definitive projectile that can be set into motion. May be used for practice, as a deterrent or traditionally to start races or competitive events.

Bolt A device of a breech firearm working by hand, spring, or expanding gas, by which cartridges are fed into the chamber, held, and extracted after firing.

Bolt head The front portion of the bolt, which normally contains the firing pin hole and to which is attached the extractor.

Bore The internal hollow component of the barrel, measured between the tops of the lands.

Breech The rear end of the chamber into which the cartridge is inserted.

Bridge The end of the barrel attached to the action.

Bullet See Projectile. In common usage, a complete round (i.e., one may purchase a box of 50 .22 caliber bullets/cartridges/rounds).

Bullet wipe A gray discolored area on the immediate periphery of a bullet hole, caused by bullet lubricant, lead, smoke, bore debris and possibly, jacket material.

Caliber The diameter of the projectile measured at its base. May be expressed in mm. or thousandths of an inch.

Cannelure Horizontally placed recessed rings around a bullet that contains lubricant to facilitate the passage of the projectile through the bore.

Cartridge The combination of components once assembled (i.e., case, primer, powder, and projectile).

Case The component of the cartridge that contains the propellant, usually made of brass (pistol and rifle rounds) or cardboard or plastic for smooth bore rounds.

Cavitation Rapid expansion of tissue due to supersonic forces generated by the projectile as it passes through an organ. In the case of high velocity projectiles, the cavity may be up to 40 to 60 times the diameter of the projectile. The greatest internal dimension of the cavity may last for several milliseconds.

Centerfire Any round of ammunition that requires a centrally placed primer in the base of the cartridge case to initiate combustion of the propellant.

Chamber The portion of the action that holds the cartridge ready for firing.

Choke An optional device that may be attached to the end of the shot gun barrel to decrease the spread of the pellets once discharged. The choke is more commonly a length of fixed barrel that has a very gradual conical taper towards the muzzle. The degree of choke is designated as half, full, modified choke, or improved cylinder.

Cock To set the hammer ready for firing — to cock the gun.

Contact range A classification of injury caused when the muzzle of the gun is placed against or very near to the skin. May be subdivided into hard contact, near contact or loose contact. Typified by abrasion rim, sooting, focal thermal injury and in the case of hard contact, a muzzle imprint.

Crimp An inward turn to the edge of a cartridge case. The crimp has two purposes — to secure the bullet and to allow sufficient pressure to build inside the case before the projectile separates from the case.

Cylinder Part of the revolver that contains the chambers. The cylinder revolves within the frame of the pistol.

Distant range A classification of injury that relates to the effect of the passage of the projectile only through the skin. The distant range shot does not exhibit stippling, sooting or thermal effect.

Double action Pulling the trigger both cocks the hammer and fires the gun.

Double barrel Two barrels set side by side, or over and under. This configuration is seen almost exclusively in smooth bore weapons.

Dry fire To operate the firing mechanism of an unloaded firearm, or one that contains a dummy practice round.

Dum dum A projectile that has been deliberately cross etched at its tip to facilitate early deformation inside the body for the purposes of increasing "stopping power."

Embolus A bit of matter foreign in the blood stream, such as fat, air, blood clot, or a projectile, which is carried along the blood vessel until such time as it lodges and causes obstruction.

Ejector A device that ejects the spent case from the chamber.

Entrance wound The point of bullet entry to the body after being shot — in common usage, the bullet hole. The diameter of the entry wound does not necessarily equate with the diameter of the projectile that has passed through the skin.

Exit wound The point of bullet exit from the body. The exit wound may be a neat round hole, an irregular laceration, or a large gaping defect.

Extractor The device that pulls the fired cartridge case out of the chamber.

Firing pin The device that strikes the primer, causing the firing of the cartridge.

Flash hole The small hole (or holes) from the base of the primer pocket into the case interior, through which the primer flash ignites the propellant.

Fouling Powder fouling. The effects of burnt propellant on the skin — seen as smudge-like sooty deposits.

Gas checks A metallic cap that protects the base of the lead projectile from the thermal effects (melting) of combustion. This also prevents gas leaking along the edges of the projectile while still in the barrel.

Gilding A layer of metal (usually a mixture of copper and tin) that coats the lead core of the bullet to prevent stripping and loss of metal as it passes through the bore at high speed.

Grain A unit of weight used for projectiles and powder charges. (1 Grain = 1/7000 of a pound.)

Grip The part of the gun that is held in the hand.

Grooves Spiral cuts in the bore of a firearm that cause a projectile to spin as it moves through the barrel.

Gunshot residues (GSR) Fine particulate material that is deposited on the skin of the firing hand. The residues may be analysed and classified under the scanning electron microscope. Most GSR is generated from the flash of the primer. GSR may contain trace elements such as antimony and barium.

Gutter wounds A grazing defect caused by the projectile striking the body at an acute angle or near tangent, causing a shallow elongated gutter like defect.

Hammer The device that drives the firing pin to strike the primer.

Hard contact A particular wound caused by the muzzle being placed firmly against the skin, characterized by a (usually) well defined muzzle imprint as well as the other characteristics of a contact range shot.

Head stamp Information on the base of the cartridge case, often indicating gauge, caliber, manufacturer's name, and other product information.

Hollow point A type of projectile having a concavity or an open tip that ensures rapid deformation on impact.

Intermediate range A range of discharge typified by stippling (tattooing) on the skin, in addition to possible thermal effect (see Stippling and Tattooing).

Intermediary target A medium that the projectile passes through before striking the victim (often glass, wood, or wire mesh). Hitting the intermediary target will deform the projectile and often lead to atypical entry wounds.

Jacket A layer of metal that protects the lead core of the projectile — usually consisting of gilding metal. High velocity projectiles require either a full or partial (semi) metal jacket to prevent stripping and disintegration.

Key hole entry A complex fracture pattern caused by the passage of a projectile at a very acute angle, creating a partial internal and external bevel to the skull on entry.

Kronlein shot An unusual injury pattern generally caused by the impact of a high velocity projectile to the skull. The brain is exenterated and remains more or less intact.

Lands Part of the internal spiral structure of a rifled barrel. The lands are the projecting component, the grooves are the recessed component.

Leading Particles of bullet torn off as it passes through the bore and that stick to the bore.

Lead snow storm A classic radiological picture often seen after the passage and partial disintegration of a high velocity projectile — seen as multiple finely divided lead particles.

Machine gun An "automatic" weapon that will empty its magazine of ammunition as long as the trigger pressure is maintained. The weapon may be handheld, supported on a tripod, or mounted on a vehicle.

Magazine The storage component that holds the cartridges in a repeating firearm.

Magnum Firearm that takes an unusually powerful cartridge.

Metal fouling The effects of the particulate metal hitting the skin as well as the projectile.

Muzzle The opening at the front of the barrel.

Muzzle break A device attached to the muzzle to reduce jump or recoil — often called a compensator.

Muzzle imprint An imprinted abrasion or superficial laceration caused by the firm application of the muzzle of the gun against the skin. The imprint is largely due to sudden and forceful expansion of soft tissue against the barrel at the instant of discharge.

Near contact A classification of range determination when the muzzle is placed near to but not hard against the skin — typified by sooting, searing and often singeing of hair (compare to hard contact and contact).

Nutation Literally meaning "nodding of the head." A characteristic of a projectile in flight before it eventually stabilizes by establishing a gyroscopic spin.

Open sights Iron sights consisting of a blade type foresight and an opened notched rear sight.

Percussion cap A small metallic cap containing percussion sensitive chemicals similar to those used in primers. The cap is placed over a nipple attached to the cylinder in black powder pistols and over the flash holes of older style rifles. The cap is struck by the falling hammer after pulling the trigger. The spark generated by ignition of the percussion sensitive chemicals ignites the propellant.

Petal A component of the plastic piston seen in shot gun shells. Generally speaking, 12 gauge shot shells deploy four petals and the .410, three petals.

Petal slap A patterned abrasion imprinted on the skin after impact from partially or completely deployed piston petals.

Pistol A short barreled firearm designed for use in a one handed grip — collectively, revolvers and semiautomatic pistols.

Piston A plastic cap that contains the lead pellets in a shot gun cartridge. The pistol contains the pellets in a tight aggregate for a short time after discharge. The piston is aerodynamically unstable and quickly falls away.

Powder A loose term for propellant, be it SB, DB or black powder.

Primer A small metallic cap containing a detonating mixture which, when struck, ignites the powder inside the case.

Projectile The component of the cartridge that is fired from the barrel and that eventually hits the target. In common usage — the bullet.

Propellant The chemical mix contained in the cartridge case responsible for the rapid combustion that ultimately ejects the projectile through the barrel. (See Powder.)

Puppe's rule A rule that states that an emerging fracture line ceases abruptly when it meets a preexisting fracture line. This simple rule allows an assessment of the sequence of shots to the skull and is invaluable in criminal proceedings. Similar lines of fracture may be seen in glass and in some veneered surfaces.

Rear sight The sight array placed near to the breech. This sight must be aligned and centred with the front sight before an accurate shot can be fired.

Recoil The explosive effect of the discharge and exit of the projectile that lifts the barrel, often markedly. The recoil also pushes the gun backwards against the shooter.

Revolver A handheld weapon (a pistol) that employs a rotating cylinder to hold the cartridges.

Ricochet In effect, the bouncing or skidding of a projectile off a surface (such as the ground, wall, or free standing object) before it hits the victim.

Rifling The spiral cut pattern on the internal surface of a barrel of a rifle or pistol (See Lands and Grooves).

Rimfire cartridge A cartridge that does not have a centrally placed independent primer. The .22 caliber cartridge is the only round now produced that is truly rimfire in design. The primer compound coats the inside of the base of the shell and is distributed in a uniform fashion by centrifugal force during process of manufacture.

Round A single complete unit comprising cartridge case, propellant, primer, and projectile. In common usage, a single bullet is one round.

Russian roulette A potentially lethal and misguided game consisting of two or more persons spinning the cylinder of a loaded pistol, placing the muzzle against the head and pulling the trigger.

Sabot A specialized solid metallic slug, surrounded by a detachable plastic sleeve. This large caliber projectile is fired from a shot gun. The sabot round, on external examination, resembles any other shot gun cartridge in common usage.

Searing A local thermal effect on the skin seen in cases of near contact or contact range discharge.

Self loader An alternative term for a semiautomatic weapon.

Semiwad cutter A bullet design often used by the target shooter. The projectile has a conical head and flattened tip rather than a conventional round nose configuration. The semiwad cutter projectile may also be semijacketed.

Shored exit An unusual exit wound typified by a wide round to ovoid area of abrasion surrounding the definitive bullet exit wound. This unusual wound pattern is thought to be due to the effects of adjacent supporting heavy clothing or support to the skin given by solid ground or an adjacent wall. The correct interpretation of the shored exit gives a fair indication of the position of the victim at the time of shooting.

Shot Small lead or steel balls that comprise the projectiles of a shot gun round.

Single action A revolver that is cocked by drawing back the hammer by the action of thumb or finger rather than by trigger pressure.

Slide That part of a semiautomatic pistol that is drawn back to cock the action.

Soot Burnt propellant, consisting mainly of carbon.

Stippling Fine punctate abrasions caused by the impact of unburnt propellant particles hitting the skin. The presence of stippling (tattooing) is necessary for the classification of an intermediate range shot.

Tandem shot The expulsion of two projectiles from a gun when the first projectile is lodged in the barrel and is then expelled by the second fired round. The tandem shot may create a complex pattern injury on the victim or cause serious damage to the firearm.

Tattooing See Stippling.

Trigger That part of the firearm moved by the finger that engages the action.

Velocity The rate of motion, usually measured in either metre or feet per second.

Wad A disc of felt or cardboard that overlies the propellant or pellets in a shot gun cartridge. Discs made of cardboard are frequently called cards.

Wad cutter A bullet design often used by target shooters. The tip of the bullet is flat rather than the conventional round nosed or tapered configuration.

Wild cat cartridges A nonstandard cartridge produced by a small company or individual.

Yaw The deviation of the long axis of the bullet from its line of flight. In common usage — bullet wobble.

Zip gun A home made firearm. These include pen guns or weapons produced after the conversion of cap pistols or starting pistols.

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