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AUTOPSY EXAMINATION OF FIREARM FATALITIES.

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Summary

As general pathologists in Malaysia are required to perform medico-legal autopsies, this paper is written with the hope that it may serve as a guide to the less initiated. An account of elementary ballistics is included because it is essential for understanding the features of wounds produced by firearms. A complete autopsy examination including a systematic approach to the injuries is advocated. The recognition and interpretation of firearm injuries can often be difficult and it is essential that all features of injuries and other relevant findings are carefully observed and recorded. Relevant observations, documentation and opinions necessary for accurate determination of the true circumstances of death are discussed.

Keywords: Firearm fatality, elementary ballistics, injury, autopsy, documentation.

INTRODUCTION

In Malaysia, the increasing incidence of firearm injuries and fatalities makes it necessary for general pathologists, and others engaged in medico-legal examination to be able to properly examine and recognize firearm injuries and other relevant find ings. The evidential value of any examination, and the conclusions therefrom, are only as good as the accuracy of the observations made and recorded. Many of the firearm injuries encountered are 'atypical' and their recognition and interpretation are difficult even for experienced forensic pathologists. Only a systematic and meticulous examination would ensure that all features of the injuries and other relevant findings are observed. In addition to examination of the body (and injuries), it is necessary to examine the scene of crime or death, clothing, and any projectile or missile recovered. The nature of an injury should not be determined on the basis of one or two, but all its features and associated findings. Many factors determine the features of a firearm injury: (1) the type of firearm and ammunition, (2) the range and angle of fire, (3) the behaviour and characteristics of the emanating (striking) projectile, (4) the presence or absence of any intervening object, and (5) the part of the body (target) struck. A basic knowledge of firearms and ballistics is necessary for proper understanding and interpretation of the injuries encountered.

ELEMENTARY BALLISTICS

The features and severity of a firearm injury are the direct result of the missile impact on, and its movement in, the body (wound or terminal ballistics). The ***force*** (kinetic energy) and ***stability*** of the missile, and the ***resistance*** of and the ***loss of energy*** in the body are the factors affecting it. The force and stability of the missile are affected by the behaviour of the projectile within the weapon (internal ballistics) and in the air or other media (external ballistics).

Weapon

The essential components of a firearm are the (1) *breach* or *butt,* (2) *trigger* and *hammers,* (3) *firing chamber,* and (4) *barrel(s).* The *muzzle* is the tip of the barrel. Firearms encountered in civilian life are *small weapons* such as machine guns, sub-machine guns, rifles, shotguns and *hand weapons* like pistols and revolvers. In general, there are two basic types of firearms:

(1) The rifled weapon, in which the inner side of the barrel is grooved spirally along its length. This causes the emerging bullet to spin around its long axis and steadies it in flight. Most weapons are of this type.

(2) The smooth-bore weapon, in which the inner side of the barrel is smooth. The shotgun, airgun and some. pistols belong to this type. The shotgun may have its barrel narrowed at the muzzle end ***(choked).*** Choking increases the range of the weapon by reducing the spread of the pellets.

The inner diameter ***(bore)*** of the barrel is

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termed the ***calibre.*** The diameter in inches is denoted by its number as **.22,** .38 or .44 or, in millimetres, as 7 mm or 9 mm. However, the traditional ***bore*** or ***gauge*** number is also used for the shotgun. This is the number of lead spheres of the same diameter as the bore that would weigh a pound, and the weapon is then referred to as a 12 or 16 bore or gauge gun.

Some weapons have more than one firing chamber and barrel. The revolver has 6 to 8 firing chambers that revolve into position for each shot. The double-barrelled shotgun has two chambers and two barrels, one of which is cylindrical and the other choked.

The general identification of a weapon is by its calibre, make and category. Thus, a weapon is referred to as a .44 Colt revolver, a 9 mm Smith & Wessen pistol, a .38 P. Walther pistol, a .22 rifle, or a 12 bore shotgun. The term ***magnum*** is added when the weapon is made for the use of magnum cartridges.

Ammunition

The ammunition used is the ***cartridge.*** It is a metal, plastic or hardboard case that contains the ***primer*** (in its metallic base), ***propellant*** and ***projectile(s).*** The cartridge size is the same as the calibre of the weapon for which it is made.

The ***bullet*** is the single projectile in the cartridge of a rifled weapon. It is a cylindrical or conical piece of lead (or its alloy) with its tip flattened, rounded, pointed or hollowed. The lead bullet deforms and disintegrates easily. This is reduced by the use of allays, metallic coatings or a cover ***(jacket)*** of metallic alloy (copper, nickel, etc.). High velocity bullets of the rifle and machine gun are fully jacketted while those of the pistol and sub-machine gun are semi-jacketted. High velocity bullets often perforate the body without disintegration or deformation.

Pellets are the multiple projectiles in a cartridge (shotgun). The size and number of lead spheres vary in different cartridges. A cartridge may have a large, single (larger than bullet diameter), 9 to 13 (equal to bullet diameter), or 150 to 750 small (birdshot) pellets. The pellets are separated from the propellant by an ***undershot wad*** of hardboard, felt or plastic material. A similar ***overshot wad*** may be present above the pellets.

The ***propellant*** may be 'black powder' or, more commonly, smokeless, nitrocellulose or nitroglycerine in the form of discs, flakes, cylindrical granules or ball powder. The quantity and quality of the propellant are increased in the larger magnum cartridge.

Firing mechanism

Manual ***loading*** is done in the shotgun, rifle, revolver and single shot pistol. The ***magazine*** or ***clip*** used in semiautomatics e.g. pistol or rifle (AK **47),** contain a number of cartridges that are pushed up into the chamber automatically ***(autoloading).*** A moving ***belt*** of cartridges is used with automatics such as sub-machine or machine guns.

The hammer is pulled back ***(cocked)*** manually in most weapons. In automatics, the initial as well as subsequent settings are automatic, whereas in semiautomatics (except the P. Walther pistol) the initial setting is manual. The pulled trigger causes the hammer to strike the ***firing pin,*** igniting the ***primer*** which results in explosion of the propellant. The gases produced are under pressure within the confined space of the firing chamber and barrel, and eject the projectile. In most weapons (autoloading pistol and rifle included), the trigger has to be pulled for each shot. In the automatic weapon, the trigger once pulled discharges the shots continuously until the magazine or belt is empty, or the trigger released.

Manual ***extraction*** of the spent cartridge is done in all manual loading weapons, with or without assistance of a lever, bolt or pump mechanism. In semiautomatic and automatic weapons, the spent cartridge is ejected automatically.

The time interval between shots varies with the type of weapon. It is longest when loading, firing and extraction are all manual. In semiautomatics it is shorter; in automatics it can be very rapid indeed. The hammer and firing-pin invariably produce marks on the base of the cartridge case. Furthermore, the rifled barrel produces marks on the bullet (basal part of its sides). These 'tel-tale' marks on the cartridge case and bullet (recovered from the scene or the body), enable the forensic scientist to identify the weapon used.

The path ***(trajectory)*** taken by the discharged projectile to the target is an arc (action of gravity) dependent on its velocity

and mass. Its velocity and stability at impact are affected by the range of fire and the density of the air (or medium).

Wounding

This is primarily dependent on the force at impact i.e. the ***kinetic energy*** (KE) of the projectile, which is given by the formula below. Note that doubling the velocity results in a four fold increase in the force of impact.

$$KE = 0.5 \times M \times V^2$$

(M = mass and V = velocity)

Primarily, velocity is dependent on the type of weapon and cartridge used. Hand weapons have a low velocity (180 — 330 **m/sec).** The rifle and machine gun are high velocity weapons (330 — 900 **m/sec).** The use of old or hand made weapons, and hand made, tampered or inappropriate cartridges cause a decrease in the initial projectile velocity. In the abnormally short-barrelled weapon, such as a ***sawn-off*** shot gun, the initial (projectile) velocity is reduced. An increase in ***range,*** deflection ***(ricochet)*** and perforation through an intervening object result in reduced velocity at impact. Higher missile velocity is seen in magnum weapons and cartridges.

The area of impact will determine the energy loss and the consequent severity and features of the resultant injury. Entry with the pointed or nose end of a missile causes a small, 'clean' injury while entry with the base or sides (as in an unstable bullet) produces a larger, irregular injury. The base of a bullet rotates around its axis of flight (the ***yaw*** or ***tail-wag)*** as it emerges from the firearm. It becomes steady in mid-flight due to its spin (rifling) and decrease in yaw. However, it becomes unstable once again at the end of its flight.

FIRE-ARM INJURIES

Firearm injuries are caused not only by projectiles but also by powder blast and the muzzle end in very close range discharge.

(1) A flash, gases, smoke, and unburnt powder i.e. ***powder blast emerge*** with the **projectile(s)** at the muzzle. These, at close range, product marks and injuries. The spark and hot gases cause ***singeing*** of hair and ***burns*** on the skin or tissues. In contact discharge, ***carbon monoxide*** in the gases imparts a cherry red discolouration to the tissues. Carbon particles (burnt propellants) are deposited in and around the injury as blackening, which is less marked or absent with smokeless powders. Unburnt propellant particles are driven into the surrounding skin or tissues as a ***tattoo.*** **Tattoo** marks of colourless propellants are not as easy to recognise as those of black or coloured propellants. Nevertheless, they can be seen as mottled, superficial puncture marks with 'granular' propellant.

(2) **The** main injuries are caused by ***projectiles*** such as bullets and pellets. In a shotgun discharge, ***wads*** may cause injury together with the 'shots' or separately (skin mark). ***Shrapnels*** from disintegrated projectiles or intervening objects may also cause injuries.

(3) **In** contact or loose contact discharge, ***muzzle*** injury occurs as an abrasion or contusion, completely or incompletely 'fitting' the size and shape of its end.

Burn, blackening, tattoo or muzzle injuries are not encountered in a very close discharge if objects or materials such as door panels, seats, clothing, etc. are interposed between the weapon and the body.

External (missile) injuries

The common injuries are ***entry, exit,*** and ***graze (glance)*** wound. The main features of entry and exit wounds are summarised in **Table** 1.

The 'typical ***entry wound,*** which has a 'clean cut' hole, is usually a high velocity missile injury. Low velocity (bullet) entry wounds, especially in loose skin areas, have edges with 'shreds' or 'tags' and can be mistaken for exit wounds.

The perforating missile stretches the skin and consequently the size of the entry wound is ***slightly smaller*** than the bullet or pellet. However, the 'tail wag' of a bullet (seen in very close or distant discharge), produces a 'larger' entry wound. The unstable or deflected bullet may enter the body by its side or base when a larger entry wound results.

A bullet (nose end) or pellet entry perpendicular to the body surface causes a ***circular*** wound. If entry is at an angle (angled

discharge or curved contour of body), the wound is ***oval.*** A shrapnel, a missile that enters by its base or side, or an irregular missile, will produce an irregular wound.

A lacemted entry wound is produced by a low velocity, unstable, or irregular missile. **The** lacerated edges are inverted and the 'shreds' and 'tags' are directed inwards. Contact discharge over a bony area often causes a split or irregular ***(stellate)*** laceration but the edges are everted. The contact entry wound in the abdominal wall may also be a large, everted laceration.

The ***'abrasion collar*** in an entry wound (inner edge) is caused by tightness of the 'hole' during perforation (stretched skin). This is uniformly wide all round in a circular entry wound. However, in an oval wound, it is broad at one margin, tapers along the two sides and is absent or minimal at the opposite margin which may show an undermined edge as well. The abrasion collar becomes darker with exposure to air. The ***contusion collar*** is seen along the outer edge of the wound. Sometimes subcutaneous haemorrhage under and around the wound may also be present. Grease and metallic particles wiped off the missile as it passes through skin produce the ***grease collar*** at the wound edges. Swabs taken will confirm its presence. ***Foreign material,*** usually from overlying clothing, may also be driven into an entry wound.

The periphery of an entry wound shows characteristic features in very close range discharge. Singeing of hair, burns, blackening, and tattoo marks are seen only around an entry wound. **The** sizes and shapes of mottled tattoo marks of colourless propellants are dependent on their **'granularity'.** These have to be distinguished from pressure and superficial puncture abrasions caused by gravel or sandy surfaces. Blood in sweat pores around an injury may also mimic tattooing.

Muzzle injury is seen only around an entry wound and may have a 'pattern'. The ***imprint*** or ***abrasion*** is complete in a firm, perpendicular contact but is incomplete in loose or angled contact.

A shotgun entry wound is single or multiple depending on the range of discharge. In very close discharge, the whole mass of pellets (and wads) enter the body producing a large, single, clean, entry wound. With increasing range, the wound gets larger. As the pellets at the periphery disperse, they cut the edges and a ***scalloped*** wound results. ***A*** further increase in range causes. some of the pellets to enter separately around the main wound. With increasing ranges, most, if not all, of the pellets separate out and multiple **small** entry wounds are seen spread out over an area proportional to the range of fire. The wads enter the body with the pellets in very close discharge only. In this, the plastic undershot wad may cause cruciate or stellate lacerations of the (common) entry wound. With increase in discharge range, the wads may strike the body separately causing an abrasion or imprint injury, usually below the entry wound. In longer ranges of discharge, no wad mark is seen on the body. As with the rifled weapon, shotgun contact discharge over bony areas produces a stellate wound with werted, lacerated edges, and usually severe internal injuries.

A ricochet (deflected) bullet entry wound is a 'large', irregular, lacerated wound with no obvious abrasion or contusion collar. Other features are usually absent wen in very close discharge.

A re-entry wound is produced when a missile that has already perforated the body, enters another part of it. The wounds in juxtaposed or adjacent areas are mirror **imaged.** The re-entry wound is usually lacerated and has inverted edges. When the wounds are apart, the re-entry wound is considerably larger than the preceding exit wound. Abrasion and contusion collars may be present.

Exit wounds are present only if the missile has sufficient force (velocity) to perforate out of the body ***(perforating injury).*** If not, the missile will be found in the body ***(penetrating injury).*** **Penetrating** injury is commonly seen with a low velocity rifled weapon, a shotgun and a long range discharge, and a low **velocity** missile. In as much as an entry wound may not have an exit wound, it may have more than one exit wound. Disintegration or break-up of a missile or bones result in fragments that may produce separate exit injuries.

The size of an exit wound is quite variable. A tumbling and unstable missile causes a large exit wound. Provided there are no bony injuries, the size of an exit wound is determined by type of weapon and **ammuni-**

tion, and discharge range. For a given weapon, the exit wounds in close, medium or long range discharges, are respectively larger, the same or smaller than the entry wound. Contact discharge at the head or abdomen produces a smaller exit wound. The pellet exit wound is much smaller than its large, 'single shot' entry wound.

Though the exit wound is usually radiate or irregular, it may be a split laceration only. The edges of the exit wound are everted and the tissue tags directed out. Characteristically the edges are free of any abrasion or contusion collars. However, if the region is supported by tight or thick clothing, straps, etc. or pressed against a firm surface e.g. a door, wall, or seat, abrasion and contusion i.e. ***showing*** can occur around the injury (viz. abrasion and contusion collars of entry wound). In some instances, the missile may even be pushed back into the tract. Spicules of bones from underlying bony injuries may be found in or out of the exit wound.

A gmzed (glance) wound is non-penetrating and results when a missile strikes a body surface at a tangent. This is usually an abraded or lacerated injury, the width of which is 'equal' to the diameter of the missile. The outer edges are often contused with the burns, singeing of hair, blackening, and tattooing seen in close range discharge.

Internal (missile) injury.

The general features of the entry and exit parts of an internal injury (tract) are given in **Table *2*.** The severity and extent of the internal injuries are primarily dependent on the loss of kinetic energy by the missile during its passage through the body. This is proportional to the 'effective' cross-sectional area of the missile and to tissue resistance. In addition to the perforation, laceration and haemorrhage caused directly by the missile, there are similar injuries around the tract from the released force. The force also compresses tissues around the passage and a large temporary ***cavitation injury*** results. After passage of the missile the cavity collapses and a narrow ***permanent tmct*** is formed. The size and shape of the cavity and tract vary with the weapon and ammunition used. Cavitation may be maximal at the entry, middle, or exit ends of the tract. Contusion, haemorrhage, laceration and rupture may occur in organs either adjacent to or 'remote' from the missile tract. The bullet may tumble in the tissues even without impact with bone or other hard tissue. **Tumbling** increases tissue resistance (increased cross-sectional area of missile path) and a wider, more severe injury results. The tumbling bullet may exit by its side or base causing a larger exit wound. It may even come to lie in the tract, facing the direction of entry. Disintegration or break-up of a bullet, or the entry of a mass of pellets cause a more severe injury. Soft lead and hollow-nosed bullets flatten and mushroom out on impact and,give rise to a wide tract or severe injury. Lead and semi-jacketted bullets and pellets may fragment on impact with hard or bony structures. These fragments, together with shattered bony pieces, not only cause extensive internal injuries but also multiple exit wounds. The hard, fully-jacketed bullet, on the other hand, often perforate the body without fragmentation (unless a bone has been struck) leaving only a narrow tract.

The direction of the internal injury and tract can be established by the presence of foreign materials, missile fragments and displaced bony spicules in the entry and exit ends of the tract. Perforation of a flat bone (e.g. skull, ilium or rib), shows a wider injury with ***bevelling*** at the exit side of the bone. Thus an injury of the head will show bevelling on the inner table of the skull at the entry side and on the outer table at the exit side. In the vertebral body, the side of entry is usually a clean hole, whereas the exit shows protruding bony spicules with or without bevelling.

The ***tmct*** is' always a straight path connecting the entry to the exit wound in perforating injury, and to the site of the missile in penetrating injury. Internal deflection of the bullet by hard (bone) tissue produces an angulated tract (at times more than once). Entry of a missile into a 'blood vessel may result in ***bullet embolism.***

In general, the features of an injury is dependent on the ***mnge of fire.*** However, at widely varying distances of discharge and depending on **weapon** type, entry wounds with similar features may be produced. In practice, the various discharge ranges are:

(1) ***contact*** or loose contact, in which the muzzle is pressed or loosely in contact with the body,

(2) ***near contact*** or ***close range,*** usually 'arms reach'(< ***1.0*** metre from the

muzzle), in which one or more features of blast are seen,

(3) ***intermediate range,*** in which the discharge is beyond 'arms reach' distance, and

(4) long range, in which the injury is only penetrating (not perforating) and at the end of the weapon's range. Intermediate and long range are also categorised together as ***distant range.***

The features of injuries at different ranges are given in Table 3A for a rifled weapon and in Table 3B for a shotgun.

The distant range cannot be estimated with any accuracy from the injury as this is dependent on the range capability of the weapon e.g. a pistol discharge at 10 metres and a rifle discharge at 100 metres would produce similar injuries. The distance of fire is estimated by the forensic scientist using the suspected or recovered weapon and suspected type of ammunition to produce target injuries similar to those found in the body.

AUTOPSY EXAMINATION

The procedures and techniques are the same as in any other medico-legal autopsy. A history of the incident should be obtained and the scene of death (or incident) examined before commencing the autopsy examination. This should include examination of clothing and radiological examination of the body. The autopsy examination proper should be a full and complete external and internal examination of the body.

History and scene investigation

A complete medico-legal history must be obtained. Often the true circumstances of death may not be known, but the history obtained from the police investigator, witnesses and relatives would guide the pathologist in the autopsy examination. Even contradictory accounts are useful, for the pathologist can look for specific features and relevant findings that would either establish or disprove any or all the versions. The number of assailants and victims, the type and number of weapons used, the relative positions of the victims and assailants, the range of fire, the number of shots, the sequence of events and behaviour of the deceased and assailants before and after the shooting, are some of the information that should be sought.

The pathologist (medical officer) examining the body at the scene not only certifies the death but also notes the posture, degree and distribution of postmortem changes present. Postmortem changes are often altered during transport of the body. Observations at the scene should include the general array and position of the body and other relevant objects. All observations should be recorded and a sketch of the scene drawn. The presence and position of any firearms, ammunitions and spent cartridges and projectiles should be carefully noted. The position of empty cartridges of automatics could inaicate the position of the assailant. The walls, roof, floor, furniture, should be examined for marks from firearm discharges. These could indicate the direction and path of the shot. The sites of blood (stains or pools) and tissues (brain, etc.) present and their relationship to position of the body (injury) are highly relevant. The direction of blood and tissue splashes would indicate the position of the deceased. The direction of blood drops and blood-stained foot prints on the ground gives the direction of movement of the deceased and/or assailant after the injury.

The body should be placed on a plastic sheet and wrapped before it is transported to the mortuary. This ensures that no material of scientific and evidential value is lost.

Examination of clothing

In the mortuary, the clothing should be recorded as they are removed from the body. Cutting of clothing is best avoided. If necessary, it should be done along the seams and around the tears or injuries present. As the pathologist is often required to identify the clothing in court, a brief but adequate description of each piece of cloting should be recorded. However, in an unidentified body, a more detailed examination and record of the clothing is necessary. The removal and examination of clothing should be carried out with considerable care, as bullets, pellets, bullet jackets, wads, etc. lying loose in or between the clothing can be easily lost. The number, size and shape of tears and holes, and the presence of burn (melting), blackening and tattooing around them should be observed. Shredded tears of an entry hole are likely to have cloth fibres driven into the underlying body injury. The size of the 'injury' should be measured and its location in the clothing determined by its distance from the shoulder seam or waist band, and from the midline. A

single entry through or over a fold in the garment can result in multiple or larger holes and tears. The distribution of blood and tissue stains on the clothing and foot wear (sole) are other relevant observations.

Radiological examination

If not the whole body, at least regions of it with injuries or projectiles, should be radiologically examined before the internal examination. Antero-posterior and lateral views of each relevant region are required to accurately locate any projectile or foreign body. The missile tract is revealed in radiographs as a trail of metallic or bony particles or pieces. Other abnormalities sucn as pneumo- or haemo-thorax, pneumo- or haemo-peritoneum or fractures can also be detected in these films.

External examination of the body

A systematic and complete external examination, as in any medico-legal autopsy, is necessary. This would include rectal temperature readings; colour, degree and distribution of hypostasis; degree and distribution of rigor mortis; the presence of pallor or cyanosis; and the states of all orifices. Blood stains and dribble marks (noting the pattern and distribution) on the body including palms and soles are useful in determining the body positions at, and/or after injury.

Specimens for forensic science examination such as finger nails or its cuttings and scrapings, and hairs are taken before the internal examination. Finger prints are best taken after the autopsy examination. If the deceased is suspected to have used a firearm, swabs of the back of the hands over the thumb, first web and index finger should be taken. Swabs of body fluids e.g. saliva are appropriate in some cases.

Examination of injury

All body injuries should be meticulously examined and recorded. A systematic examination, region by region, ensures that no injury, however trivial, is missed. Each injury is best examined with a hand lens to determine (a) whether it is a firearm injury, and (b) the type of injury. Each firearm injury should be examined for its size, shape, edges, direction of tissues, the presence or absence of 'collars', surrounding blast features and the presence of foreign bodies. A tentative identification of the entry and their exit wounds can be made from the injury features and radiological findings. A search for concealed injury (such as in the eye, mouth cavity, arm pit, perineum) should be deligently made especially when the number of entrance and exit wounds do not tally. In general, the total number of entry wounds in rifled weapon injuries should be equal to the sum of the total number of exit wounds and missiles found inside the body, minus the number of bony and shrapnel exit wounds.

No. of entry wounds =
No. of exit wounds +
No. of missiles in body –
No. of bone/shrapnel exit wounds

The measured size of an entry wound is the diameter in the circular wound and the length and width in other wounds. This measurement should include the abrasion collar. The size of the penetrating bullet can be determined from the diameter and/or width measurements.

The degree and extent of tears and fissures in the lacerated wound (entry or exit) should be noted. A 'clean' entry wound, with 'fine lacerations' of edges, would indicate an entry in loose or folded skin or a low velocity missile. In the oval or angled entry wound, one margin is contused or undermined. The direction of free, lacerated edges and underlying tissues are .significant. However, prior washing or dressing of the injury invalidates the value of this observation.

All entry wounds invariably have an abrasion, contusion or grease collar. The direction of entry in the oval wound is from the broad part of the abrasion collar into the undermined edge. In an atypical or suspicious entry wound, determination of its type can be made from the swab taken of its edges showing the presence of a grease collar; Cytological examination of the washings and microscopy of the injury are other useful investigations.

Blast features are found only around an entry wound (close range). Scorched skin and singeing of hairs are easily recognized. Blackening may be dificult to see in dark-skinned bodies and in smokeless powder discharges. When in doubt, a swab taken around the wound can be analysed for its presence. Tattoo marks of black or coloured propellants are easily seen. However, colourless powder tattoo marks may be

difficult to see and, furthermore, have to be carefully distinguished from other superficial puncture abrasions. The presence and nature (type of ammunition) of propellant can be determined from the swabs taken. A proper cleaning of the skin will wash away blood in sweat pores that mimic tattoo marks. The shape and size of a tattoo area along with the 'density distribution' of marks is helpful e.g. an angled discharge leaves an oval or parabolic pattern. In contact or loose contact discharge, blast is driven into the injury, and the underlying tissues become cooked, blackened or tattooed. Sometimes the tissues are 'cherry red' in colour due to presence of carbon monoxide.

Detailed observations of size (measured), shape and pattern of a muzzle end injury and its relationship to the entry wound are useful in the identification of the causative weapon. The pattern of injury caused by a weapon can be altered e.g. attached silencer. A muzzle end injury may be seen over or across the lacerated edges of a contact entry wound.

The single, large, circular or oval entry wound in close range shotgun discharge may also have radial or cruciate lacerations of its edges due to entry of the plastic wad. A separate circular or crescentic wad mark (abrasion or superficial laceration) when present is usually seen below the shotgun entry wound.

The location of a firearm injury must be accurately determined. This is by reference to anatomioal (bone) landmarks of the body. At least two measurements perpendicular to one another should be made. The level of injury is also important and can be ascertained from its vertical distance from the top of head, the buttocks (coccyx) or the heel.

The presence of a number of injuries over a 'small area' is suggestive of shotgun injury. The small size of these injuries, the finding that they are all in the same direction and the presence of pellets inside the body are characteristic. Rapid automatic fire can cause injuries similar to shotgun SG or SSG cartridge discharge, but the injuries are usually perforating and the missiles present are bullets.

Probing an injury often creates false tracts and is not the method of choice to determine direction of tracts. In penetrating or perforating injuries of the skin and soft tissues (tunneling injuries), probing is acceptable.

Internal examination of the body

The routine procedures and techniques are similar to other medico-legal autopsies. Skin incisions are deviated to the side opposite to the suspected direction of injury and the skin and muscles are 'flapped' in layers. This will facilitate visualisation and enable the internal effects of blast (in contact and loose contact), the direction of tissues and foreign bodies in the tract, and the direction of the tract to be observed accurately. Often the tract through the skin, muscles and bony cage appears to be discontinuous i.e. not underlying one another. This is because the position of the body at autopsy is different from its posture at the time of injury.

Blood and clots in body cavities should be measured. A search for projectiles and shrapnels lying free or stuck in the inner surface of body cavities may be fruitful; blood clots may have to be crushed to detect their presence. Any foreign material found should be kept for further forensic examination.

The removal of internal organs can follow routine practice. An en block dissection of thoracic and abdominal viscera is necessary if the missile tracts involve both chest and abdominal organs. As in the external examination *in situ* probing of tracts is not advisable. It is usually too difficult to mobilise and 'position' tissue and organs to 'the body posture' at the time of injury for the probe to be passed correctly. Hence, the tract direction is best determined after the removal of all organs, by passing a probe to join the entry and exit wounds in the body 'cage'. The direction of the tract in organs and tissues is determined separately and then considered with the former to deduce the correct body posture at the time of injury. It is essential that these observations are properly recorded.

The different structures in the tract (from entry to exit) and the nature of injuries in them should be observed. Sectioning of organs should preferably be across the path of the injury tract. The 'shape' of the tract is ascertained by the height and width at different levels of its path. The degree and extent of haemorrhage around the tract and presence of remote injuries should be accurately noted. More than one tract may be present if a bullet or pellet has been deflected inside the body. This is usually the case in the

brain with an angled shot to the head. The point of deflection in the bone is often visible only as a depressed mark or fracture of the inner table. Any bevelling on the inner or outer surface of a flat bone is invaluable in deter mining the direction of the perforation. Furthermore, a broader bevelling in one end (viz. abrasion collar) gives the direction of the angled entry. Even comminuted bone pieces (e.g. skull) can be 'pieced together' and the perforation and its features determined.

As far as possible, all projectiles and sharpnels found in the body should be removed for further forensic examination. In shotgun discharge (especially birdshot) it is not possible and unnecessary to remove all the'pellets. The removal of a bullet should be done carefully without causing any markings on it. A difficult removal is aided by holding the bullet at its tip by forceps and extracting it. All bullets, pellets and other foreign bodies removed should be placed in separate labelled containers denoting the site of removal as well. An adequate description of every foreign body removed will facilitate its identification in subsequent court proceedings.

Samples of blood, urine and body fluids for toxicological and other forensic examinations should be taken as in any other medico-legal autopsy.

Documentation

The use of a medicolegal autopsy examination protocol is recommended for both examination and documentation in firearm fatalities. This will ensure that all necessary medico-legal observations, including relevant negative ones, are made and properly recorded. The recording should be made either at the time of examination or soon after. This original record should be as neat as possible for it may be called for (and be produced) as a document in legal proceedings. All features of the injuries and other findings supportive of the subsequent opinions expressed should have been recorded in the original document. Factually unsubstantiated opinions are unacceptable to the courts.

Photographs and ***diagrams*** should be made to supplement even very well written notes and reports. Photographs taken should be of the clothed as well as unclothed body. The relationship of injuries to one another, especially when in the same body region, must be clearly seen. In addition, close-up photographs of each injury should be taken to show its features. The presence and position of bullets, pellets, shrapnels, waddings, bony pieces, etc. are best illustrated by in ***situ*** photographs. Photographs of clothing showing missile tears and holes, missiles and other foreign bodies removed are also very useful. Diagrams make the understanding and interpretation of the injuries much easier. This should be done with considerable care especially when photography is not possible. The injuries (findings) should be numbered and marked proportional to the size of the diagram (drawing) preferably with different colours to denote the different types of injuries and their features.

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TABLE 1

FEATURES OF EXTERNAL INJURIES

	Entry wound	Exit wound
Wound	Clean, regular, 'funnelled'	Irregular
Size	Small	Large
Shape	Circular/oval	Split/radiate
Edges	Sharp/inverted	Lacerated/everted
Collar	Abrased, contused, greased	
Tissues/foreign material	Inward driven	Outward driven
Periphery	Scorched/singed, blackened, tattooed, abrased/imprinted	

TABLE 2

FEATURES OF INTERNAL INJURIES

	Entry wound	Exit wound
Soft tissues	Inward laceration	Outward laceration
Bone	Inward bevelling, spicules driven in	Outward bevelling, spicules driven out
Tract	Diameter (shape, size and depth)	

TABLE 3

RANGE AND ENTRY WOUND CHARACTERISTICS

(A: Rifled weapon B: Shotgun)

	Range	Region	Wound	Bum	Blackening	Tattoo	'Collar'	Others
A:								
	Contact	Skull	stellate	±	±	±		muzzle injury, CO in tissues
		Abdomen	large laceration	±	±	±		muzzle injury CO in tissues
		Others	circular/oval	±	±	±	±	muzzle injury CO in tissue
	Close Up to 15 cm		circular/oval	+	t	t	t	CO in tissues ±
	15 to 30 cm		circular/oval	–	t	t	+	no CO in tissues
	30 to 60 cm.		circular/oval	–	–	t	+	no CO in tissues
	Distant Over 1.0 m		circular/oval	–	–	–	+	
B:								
	Contact	Skull	large laceration-disruption	±	±	±		muzzle injury CO in tissues
		Abdomen	large laceration	±	±	±		muzzle injury CO in tissues
		Others	circular/oval	±	±	±	±	muzzle injury CO in tissues
	Close Up to I5 cm		circular/oval	+	t	t	±	CO in tissues wad inside body
	15 to 30 cm		circular/oal	+	t	t	±	wad inside body
	30 to 60 cm		circular/oval	–	t	t	±	wad inside body
	60 cm to 1.0 m		circular/oval	–	–	–	±	wad inside body
	1.0 m to 2.0 m		scalloped	–	–	–	±	wad inside body
	2.0 to 3.5 m		single, large with scatter	–	–	–	±	wad mark on skin
	Over 18.0 m		all scattered	–	–	–	±	no wad mark

$$\text{Range in metres} = \frac{\text{Dispersion in centimetres}}{4\ (3 \text{ if choked})}$$

Abbreviation: CO = Carbon monoxide.