FORENSIC ANALYSIS OF 12-GAUGE SHOTGUN FATALITIES: WOUND MORPHOLOGY AND RANGE ESTIMATION

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Abstract
Fatalities from shotgun discharge present a challenging problem to forensic investigation as a result of the inherent ballistic variability and distinctive wound morphology of 12-gauge bullets with varying shooting distances. The following article presents an extensive forensic analysis of 12-gauge shotgun wound, focusing on the diagnostic significance of wound morphology, pellet spread, and tissue damage in range estimation. Through correlation of external wound pattern with internal damage morphology and external features and radiologic findings, the case report reflects indicative markers like soot deposition, pellet diameter of dissemination, abrasion collars, and intrapelvic fragmentation. Combination with postmortem computed tomography (PMCT), histology, and scene reconstruction allowed precise calculation of firing distance and shooter azimuth. The forensic analysis clearly differentiated suicidal from homicidal patterns by ruling out spontaneous or staged options. Recommendations are provided for standardized crime scene and autopsy documentation to enhance evidentiality and legal admissibility. Results confirm that interdisciplinary approaches and technology use, with a focus on shotgun wound forensics, provide validity to conclusions throughout investigative and court proceedings.

INTRODUCTION

12-Gauge Shotgun

12-gauge shotgun is the most prevalent and uncomplicated weapon utilized in both criminal and civilian cases. Its simplicity, ammunition forms, and killing capacity in in-close-ranges make it the most common gun to be analyzed by forensic science, specifically in cases of homicide, suicide, and accidental shootings. Familiarity with the technical, historical, and forensic characteristics of 12-gauge shotguns is important not to misinterpret their injuries, firing ranges, and judicial decision in medico-legal practice.

1.1 Overview of 12-Gauge Shotguns in Crime and Justice

12-gauge shotgun plays a pivotal position in law enforcement and criminal activity because of its unstoppable close-range stopping power. In contrast to handguns or rifles, the shotgun discharges many projectiles (pellets) or a single high kinetic energy large slug and massive tissue disruption. Low precision requirement, low recoil, and widespread availability have made shotguns guns of convenience in rural violence, domestic violence, gang violence, and celebrity robberies [1].The shotgun is generally the focal firearm in criminal cases because it complicates wound pattern issues it presents and because range estimation based on pellet spread is impossible to assign. Forensic examiners need to distinguish between contact, near-contact, and far wounds—each presenting specific effects on crime scene reconstruction.

1.2 Historical Usage and Evolution

Historically, shotguns have developed from smoothbore muskets of the 17th and 18th centuries used to hunt birds and also for light skirmishes in the military. "Gauge" terminology was used to refer to the bore size in terms of how many balls of the same bore diameter would weigh one pound. Twelve of these balls will weigh one pound for the 12-gauge and hence earn the gun its name [2].Shotguns in the 19th century changed from flintlock to percussion cap and then to breech-loading cartridges. All this improved the speed of reloading and the firepower. Shotguns evolved in recent times towards tactical police and military use with semi-automatic and pump-action designs [3].

1.3 Ammunition Versatility and Function

One aspect that distinguishes shotguns, particularly the 12-gauge model, is their flexibility in ammunition. The same gun can fire a myriad of loads—birdshot, buckshot, slugs—each of which leaves significantly different wound patterns and ranges of effectiveness. This makes the investigator's task an advantage and a challenge in forensic application. They all consist of a paper or plastic casing, wad (fiber or plastic), powder, primer, and load of projectiles. The type of ammunition is crucial in internal, external, and terminal ballistics—and thus tissue injury depth and pattern [4].

1.4 Mechanism of Various Shotguns

Various shotguns utilize different mechanisms of operation that decide how forensic scientists analyze them. The most prevalent shotguns include: Pump-action: Involves chambering of every round manually by fore-end sliding. Police prefer them mainly. Semi-automatic: Automatically stops the next round through gas or recoil energy.Break-action (single or double-barrel): Opens on a hinged action for hand-loading and ejection, mainly utilized for hunting and target shooting. Bolt-action and lever-action: Uncommon but sometimes found in forensic examinations [5].Mechanical type determines the maximum number of shots discharged, residue deposition, and wadding retention—factors that are critical to autopsy interpretation and the reconstruction of the scene.

1.5 Types of Ammunition and Effects

1.5.1 Birdshot

Birdshot shells contain many small pellets (e.g., #7 or #8 size) to shoot small game or for practice. Birdshot at close range in forensic scenarios can potentially produce vast, destructive wounds from focused energy transfer, usually a single large entrance wound [6]. With greater ranges, pellet dispersion produces less fatal but more scattered injuries, making range estimation challenging.

1.5.2 Buckshot

Buckshot has fewer pellets with a greater diameter (e.g., 00 buckshot: 9 pellets of 8.4 mm). It is the most prevalent ammunition used in homicidal shotgun attacks because it is highly lethal and effective against the human target. Wounding is typically described as consisting of multiple large wound channels, massive tissue cavitation, and primary hemorrhagic shock [7].

1.5.3 Slugs

Slug rounds discharge a single large metal projectile, essentially turning the shotgun into a high-powered rifle. Slugs produce very penetrative wounds, usually exiting the body, and can easily be mistaken for handgun or rifle injuries. Careful distinction requires special forensic analysis to identify slug wounds from other wounds by entry shape, depth, and retained metal [8].

1.6 Shotgun Design: Traditional vs. New

Conventional designs, i.e., over-under and side-by-side break-action, continue to be favored for hunting and recreational purposes. New designs-tactical shotguns-being among them feature extended magazines, pistol grips, folding stocks, and optical sights, designed for police or military applications [9].From the forensic perspective, recent changes may influence pellet velocity, pattern of spread, and wound severity. Changes to the choke, which limits the muzzle for the sake of pellet dispersion, also have major effects on wound characteristics and may impact distance interpretation if not factored into consideration.

1.7 Application in Notorious Offenses

Shotguns have featured prominently in some infamous crimes. The 1989 Montreal École Polytechnique massacre was committed with a pump-action shotgun, and shotgun application has been demonstrated in some home homicide cases due to their availability in the home [10].Forensic examiners can be alerted that most illegal or improvised shotguns ("country-made" weapons) can be missing serial numbers, proper maintenance, or even standard bore/choke configurations. These are more challenging to match forensically, particularly in less restrictive gun control jurisdictions.

1.8 Shotgun Injury Patterns by Range

Shotgun wounds are relatively heterogeneous depending on the shooting distance. Contact wounds characteristically have such characteristics as muzzle imprint, massive tissue laceration, gas expansion in the internal cavities, and soot deposition within in the wound. Near-contact shots have less prominent soot and stellate tears. Intermediate range wounds have the satellite pellet holes with a central defect, and far injuries may appear as multiple distinct pellet entries with minimal tissue damage per entry [11].Such morphological evolution enables forensic pathologists to make an approximation of the firing distance, though anatomical location, attire, pellet deformation, and environmental obstructions can mislead the interpretation if not properly placed in context.

2. Terminal Ballistics and Wound Morphology

Terminals ballistics of 12-gauge shotguns should be known to forensic pathologists, criminal investigators, and medical-legal examiners who deal with firearm death analysis. Shotguns, particularly 12-gauge, possess distinctive ballistic characteristics owing to the various types of ammunition used and the spreading of projectiles, which produce an immense amount of wound morphologies. The impact injuries are greatly dependent upon range, angle, and impacted anatomical site. Accurate interpretation is essential for range estimation, intent (suicide or homicide), and court expert testimony.

2.1 Principles of Shotgun Wound Ballics

Terminal ballistics describes the trajectory of the projectile upon striking and engagement with a target—forensic targets being human tissue. 12-gauge shotguns, as opposed to single-projectile firing weapons, are designed to discharge a quantity of pellets (buckshot or birdshot) or one massive single projectile (slug) and create different wound morphology. A shotgun cartridge will discharge shot on firing, which starts expanding once it has left the barrel. This spread varies with range and is affected by aspects of barrel length, choke configuration, and shot composition [6].Wound ballistics of the shotgun can be divided into three broad stages:

Internal ballistics – ignition of propellant and bullet behavior inside the barrel.

External ballistics – pellet/slug behavior outside the barrel.

Terminal ballistics – impact and tissue interaction.

Every stage impinges on the resultant injury, but terminal ballistics—whereby projectiles interact with tissues—is specifically important in forensic reconstruction. The pellets do not behave collectively when shot and interact with skin, underlying tissue, and bone in multifaceted manners, especially when hitting at oblique angles or clothing.

2.2 Energy Transfer and Tissue Disruption

Pellets from shotguns impart kinetic energy to tissue when they hit. Degree of injury is dependent on the kinetic energy ($KE = \frac{1}{2} mv^2$) of a single pellet or slug. Shotguns fire several low-mass pellets at relatively low speeds compared to firearms but whose cumulative energy at close range is deadly [8].At close ranges (less than 10 meters), the mass of the shot acts nearly as a single projectile, imparting energy and explosive tissue devastation with colossal cavitation. The energy is delivered to skin, soft tissues, organs, and bones, typically most commonly leading to lethal hemorrhage, evisceration, or fragmentation of intracavitary structures. At intermediate and further ranges, the dispersed pellets minimize general tissue disruption, but there remains several penetrating trauma.Severity of wound also differs with the density and elasticity of the tissue struck. Liver and muscle, for instance, dissipate energy in a different manner than lung tissue or in comparison with the cranium. Bony blows cause secondary fragmentation, and it complicates wounds [12].

2.3 Morphological Classifications by Range

Forensic understanding of wounds conventionally classifies shotgun wounds on range estimation. Morphological characteristics at each range provide useful clues to reconstruction.

2.3.1 Close-Range Wools (0–10 meters)

Close-range wounds (particularly < 1 meter) are marked by:

- Individual, large, irregular entry wounds with extensive tissue destruction
- Extensive scorching or charring due to hot gases
- Presence of soot (carbonaceous material) in the wound
- Muzzle impression due to contact pressure
- Cavitation of tissues due to gas expansion

Pellets are also buried within the body in a dense clump, replicating single-projectile high-velocity wounds. Propellant gases are forced into the body at contact or near-contact ranges, leading to expansion within the body and usually shredding organs, a characteristic commonly associated with suicides to head or chest [13].

2.3.2 Mid-Range Wounds (10–30 meters)

At this distance:

- Satellite pellet holes are seen around the central defect.
- The central wound remains large, but is irregular-edged.
- Soot and tattooing can still be seen but diminished.

This distance provides the optimum conditions for good range estimation as both central hit and peripheral pattern of dispersal are encountered. Intermediate-distance wounds are frequent in homicidal assaults when the attacker is at a distance but not necessarily at a distance great enough to enable full pellet separation [14].

2.3.3 Wounds at more than 30 meters (Long-Range Wounds)

In longer distances:

- The pellets are separated and produce discrete puncture wounds.
- No soot, scorching, or tattooing.
- Central defects vanish, and wounds look like ones from multiple small-caliber gunshot injuries.

Far shots can be confused with handgun or submachine gun assault if pellet number and caliber are ignored. Pattern of expansion, inter-pellet distance, and radiography are valuable in identification [15].

2.4 Morphological Indicators of Range

Four notable morphological indicators are helpful in estimating the firing range of a shotgun:

Soot Deposition: Black carbon soot is typically deposited within and around the wound at contact or near-contact distance. It falls off very quickly with distance and is typically absent more than 50 cm.

Tattooing (Stippling): Is produced by unburnt or partially burnt powder grains striking the skin. This forms very small punctate abrasions and is typically visible up to 100 cm. Its absence does not necessarily indicate distant firing if barriers are worn [16].

Pellet Patterning: Wounding spread at medium to extended ranges may be estimated by measuring pellet impact-to-impact distance and thereby estimate range with a known load and choke setting.

Wadding and Muzzle Imprint: Plastic or fibre wads can be imbedded in tissue at close range, especially under 2 meters. Muzzle imprints (related barrel-shaped burns) in direct-contact wounds [17].

Radiological methods such as X-rays or CT scans can complement visual examination by tracking pellet path traces and concentration within tissues. 3D reconstructions are best utilized to reconstruct angles of entry as well as confirmation of range [8].

2.5 Pellet, Slug, and Specialty Round Use
Characteristics of the projectile fired have a major influence on wound morphology:
Birdshot: Many small pellets, low individual weight, high overall energy. Disabling wound at close range; unpredictable superficial punctures at distant range. Commonly utilized in accidental or crowd-control shootings.

Buckshot: Larger shot (e.g., 00 Buck), 8–12 per shell. Causes huge cavitating wounds. Commonly used in homicides and police encounters because of added stopping power.
Slugs: Single heavy bullet (~28 grams). Causes huge entry and possible exit wounds. Can be easily confused with high-velocity rifle fire if not identified. More range than shot and creates linear wound channels [6,14].
Other specialty rounds (rubber shot, bean bag) utilized in riot control are still lethal at close range by virtue of blunt trauma or penetration injury to the susceptible target areas like the chest or head.

2.6 Anatomical Site and Angle Impact
Anatomical site and angle of entry are crucial factors that determine the character of shotgun wounds:

Head and Neck: Close-range injuries to these regions usually lead to evisceration of soft tissue, smashing skull fractures, and extrusion of the brain. Common in suicide attempts [13,14].

Thorax and Abdomen: Extremely high mortality due to involvement of main blood vessels, heart, liver, or lungs. Internal bleeding is one of the most common modes of death. The size of the entry wound and the involvement of the organs provide clues about the direction of fire and range [15].

Limbs: These exhibit less violent trends but with deflection of pellets and fractures making the analysis complex. Ricochets or secondary trauma may simulate other kinds of injuries.

Oblique Angles: Entry wounds are elliptical or irregular, and pellet courses within the body are angular, making the trajectory analysis complex. Exit wounds, if they occur, can be confused with additional entries unless internal courses are reconstructed through imaging [12].

3.1 Scene Investigation Protocols
A quick and concerted effort is essential to preserving physical, biological, and ballistic evidence in shotgun shootings. Investigators have to document first, to avoid contamination, and have to work cooperatively with firearms examiners and forensic pathologists.

3.1.1 Initial Response and Photography
After securing the scene, investigators first document the entire scene. Absolute shots are overall, mid-range, and close-up shots of the body, gun, bloodstain pattern, and wounds evident, all with measurements [18]. Body orientation, direction of fire (if any), cartridge expenditure site, and wall or furniture pattern effects have to be documented before any object is taken away. Photographic documentation of entrance wounds, muzzle imprints (if present), and possible struggle or movement indicators is also required. Documentation is methodical to facilitate the accurate reconstruction of the shooting incident.

3.1.2 Recording and Evidence Collection
A grid or zone search in the field can be used to document:
- Empty shell casings
- Shot or pellets in surfaces
- Wadding material
- Clothing
- Trace evidence (hair, fibers)

Each item is documented where it is discovered, documented, and packaged using routine chain-of-custody procedures [16]. Each item is documented on a scene diagram or sketch where the item is discovered. Wads and shells can be used in identification of ammunition type and manufacturer deployed, traced back to a suspect or a weapon. Scene examiners also need to look for impact marks from stray shot on surrounding objects (floors, windows, walls) that can help in angle and range of fire estimates.

3.1.3 GSR and Wadding Collection
Gunshot residue (GSR) and wadding can be extremely valuable in estimating range. GSR is recovered using

adhesive stubs on the hands, face, or clothing of a victim or suspect [11]. Detection of GSR in shotguns is largely doubtful depending on the load, clothing, and whether recently the weapon has been discharged or not.Wadding is of special significance in shotgun trauma: a fiber or plastic wad will be present in the cavity of the wound when fired at close range, or can be recovered from the scene. Recovered, they are useful in identification of gauge and shell type. Identification of the wad by brand or shell can result in valuable forensic connection.

3.2 Autopsy and Documentation of Injury

When the body is taken to the forensic morgue, the medical examiner performs a complete external and internal examination. In shotgun deaths, the wounds are vast and multilayered and need to be photographed anteriorly, before and after dissection.

3.2.1 External Wound Analysis

External examination starts with a general survey of the entire body in order to look for:

- Entry wounds
- Exit wounds
- Satellite pellet holes
- Soot, tattooing, or muzzle imprint
- Clothing damage correlation

Close-range injuries will tend to have blackened edges (soot) and tattooing by unburned powder, while those in the intermediate range present satellite holes or scalloped margins surrounding a central defect [20]. Gas from the explosion can cause muzzle imprinting and tissue eversions in contact range. Photography is done before cleaning to help preserve trace evidence. The site, diameter, and related skin changes are documented and described for all the wounds. In suicidal injuries, intraoral or submental wounds occur frequently and should be documented well.

3.2.2 Internal Damage Mapping

Internal inspection is conducted by tracing the path of pellets or slugs, observing organ involvement, and attempting energy transfer estimation. Injuries to thorax, abdomen, and cranium have to be investigated in stages to judge vascular disruption, tissue laceration, and secondary fracture [21].Radiographic visualization (CT or X-ray of the whole body) is generally done before dissection to locate pellets, observe spread, and assist internal examination. CT allows 3D mapping of trajectories of injury and makes estimation of range and angle easier. Deep tissue pellets left behind during autopsy can still be localized with radiologic markers. If the projectile exited the body, exit wound is compared to entrance for size, beveling, and irregularity. All these dictate the trajectory, angle, and potential ricochets of the projectile.

3.2.3 Pellet Recovery and Classification

Every recovered pellet is weighed, cleaned, and classified. Pellets are different sizes based on ammunition utilized (e.g., birdshot, buckshot), and recovery provides positive shot type and spread identification [22]. Deformed pellets can be indicative of contact with bone or hard surfaces.Classification encompasses:

- Diameter and weight measurement
- Identification of material composition (e.g., lead, steel)
- Matching to known ammunition

Recovered wads are also documented photographically and searched for brand stamps. Where applicable, plastic sabots or buffer material is also recovered and used in ammunition configuration reconstruction.Recovered bullets are taken for ballistic analysis for comparison with test fire samples, where the suspected firearm is recovered. Fiber, tissue, and GSR may be analyzed from pellets and wads for further linking of the shooting incident.

3.3 Radiological Imaging

Radiology is critical in shotgun wound examination because of multiplicity of shots and complexity of internal scatter.X-ray for Pellet SpreadPlain X-rays are the radiologic signature for detection of shotgun pellets before autopsy. They provide an approximation of:

- Pellet count
- Spread diameter
- Depth of penetration
- Presence of retained wadding

Pellet scatter on X-ray can provide hints regarding the range of fire: close-range discharge is identified by clusters of pellets which are close together, and diffuse pellets over a wide range indicate distance [1,8]. X-rays are also useful for the analysis of trajectory when there are multiple wounds and exits are unclear.

CT for Trajectory and Tissue Damage
Computed tomography (CT) or multi-slice or spiral CT gives volumetric imaging of:
- Bone fracture
- Vascular disruption
- Pellet trajectory
- Gas and tissue expansion

CT scanning is also very helpful in **cranial trauma**, where pellet tracks must be followed through complex bony pathways [12,8]. CT is also helpful for non-invasive virtopsy (virtual autopsy) to aid in legal and religious need for preservation of evidence.
With air embolism, gas tracking, or gross hemorrhage, correlation with wound topography is permitted on CT and it can also detect secondary projectiles, i.e., bone splinters.

3.4 Histological Analysis
Histology enables microscopic confirmation of wound parameters and may be used to differentiate antemortem from postmortem trauma.
Vital Reaction Testing
The assessment of wound vitality includes the observation of biological responses such as:
- Hemorrhage
- Inflammation
- Tissue edema
- Leukocyte infiltration

These markers are evidence that the wound was inflicted while the heart was beating, something that is required to determine the temporal relationship between injury and death [13,16].
Entry Wound Histology

Histological examination can also differentiate:
- Entry from exit wounds
- Direction of pellet impact
- Embedding of powder particle

Charred margins, soot, and powder stippling may be discernible on histological sections when they are not visible macroscopically [7]. This is important when the skin has been altered by postmortem decomposition, surgery, or environmental weathering.

3.5 Ballistics Laboratory Comparison
Ballistics laboratories duplicate and compare shooting conditions using the found weapon, cartridge, and tissue.

3.5.1 Duplication of Patterns and Test Firing
Ballistics technicians perform test firing in controlled conditions using the suspect firearm and ammunition, typically at different distances into:
- Ballistic gelatin
- Foam
- Cardboard or fabric targets

This creates a pellet pattern of known range to contrast with patterns of injury on the victim [2,5]. Correlation of shot spread with true wounds is able to give an approximate discharge range with high confidence.
Controlled discharge demonstrates also:
- **Influence of choke and barrel length**
- **Velocity reduction by range**
- **Pattern deformation by clothing or obstruction**

3.5.2 Shot and Wad Analysis
The thorough analysis of recovered wads and pellets determines:
- Pellet caliber and form
- Deformation level
- Material (lead, steel, alloy)
- Producer and wad type (plastic, fiber)

Certain shotgun cartridges imprint unique marks on wadding or buffer that can yield track-back to special brands or batch numbers [3,6].Other markings in the barrel transfer trace striations to slugs or slug held within sabot and enable comparative identification.
These comparisons are analogous in procedure to rifled barrel projectile comparison [5].

3.6 Trace and Residue Analysis
GSR Analysis (SEM and AAS)
Gunshot residue (GSR) is examined by:
Scanning Electron Microscopy (SEM) to identify shape and elemental signature
Atomic Absorption Spectroscopy (AAS) for lead, antimony, barium detection
Although GSR from shotgun powder burning discharge is recognizable from pistol/rifle discharge, close-range firing still leaves residues on the hands,

face, and surrounding skin of the victim or shooter [1,19].GSR on the skin near wounds facilitates range grouping (e.g., tattooing, stippling). GSR is less effective at marking shooting ranges and can be lost through washing, weather, or time.

Infrared and Elemental Imaging

Infrared photography, ultraviolet light, and X-ray fluorescence (XRF) assist in the detection of:

- Burn areas not apparent under normal light
- Metal deposits near entrance wounds
- Wadding impressions on skin or bone

These methods are very useful when dealing with clothing being pulled off or coloration of the skin and can be used to non-destructively map residues [6,17].

3.7 Digital Tools and Scene Reconstruction

Recent advancements have brought with them very potent tools for 3D reconstruction, i.e., crime scene modeling and injury trajectory simulation.

3D Modeling

Laser scanners, photogrammetry, and CT data have the ability to produce high-resolution 3D models of:

- The victim's injuries and internal anatomy
- Crime scene geometry
- Bullet/pellet paths

This enables forensic examiners to model body posture, calculate shooter height or position, and evaluate hypotheses such as ricochet or back-spatter [8,12].

3D models have been testified in court to provide a visual representation of wound tracks, augment expert opinion [5].

Trajectory Simulation

Trajectory rods mounted at autopsy or scene reconstruction are referenced with:

- Entry and exit wounds
- X-ray/CT scans
- Scene photography and laser imaging

With incorporated ballistic coefficients and known ammunition data, software can simulate:

- Projectile curves (arc or angle)
- Obstructions
- Intermediate targets (i.e., walls, glass)

These drills improve estimation of range and verify if the shooter's position agrees with utterance or hypothesized positions [5,13].

4. Case Study: Murder Case In Pakistan

4.1 Incident circumstances

Sheikhupura police in Punjab were deployed at 21:10 hrs on 15 April 2025 to a shots fired incident at a roadside eating house. Victim Asif Nawaz, 30 years old, was found lying beside a motorcar with multiple gunshot injuries. An argument had been witnessed involving the victim moments before the shots were heard. The victim was found dead at the scene. The case was pressed under Section 302 PPC with the relevant enhancement of terrorism, considering the public nature of the assault and the cause of panic [23].

4.2 FIR and Initial Evidence

The local police registered a First Information Report (FIR) against "murder by unknown persons." At the crime scene, the investigators found a spent cartridge of 9mm on the victim's left side and another empty round next to his wallet. Blood splatter was noticed on the ground and car door. The witnesses saw one man run away and heard three or four rapid shots [24].

4.3 Crime Scene Documentation

4.3.1 Blood Collection

Arterial spurt and pooling, especially around the thigh, were observable blood patterns. Blood samples were gathered by investigators to be tested for DNA and toxicology. Forensic examination by confirmatory tests of origin and genetic profiling was conducted by the Punjab Forensic Science Agency (PFSA) [25].

4.3.2 Pellet Dispersal Analysis

Though no shotgun pellets were fired, bullet impact marks and trajectory were examined with the help of trajectory rods. There was a tungsten fragment, a probable ricochet, inside the door of the nearby parked car. Wound distribution in space and entry points indicated a horizontal trajectory from mid-range (~17 meters) [26].

4.4 Autopsy Findings

A complete post-mortem was conducted at Sheikhupura District Headquarters Hospital.

4.4.1 Left Thigh Entry Wound

A single entry wound due to a bullet on the upper left lateral thigh was about 0.8 cm in diameter with minimal abrasion and no soot, which indicated an intermediate range of firing (5). The bullet inflicted damage to the soft tissue but not a fracture of the bone.

4.4.2 Abdominal Damage

The second bullet came in from the left of the abdomen and penetrated the small intestine, with approximately 800 mL of hemoperitoneum estimated. The bullet was embedded against the posterior peritoneal wall. Internal injuries were the reason for the copious internal bleeding [27].

4.4.3 Arm and flank wounds

Two of the other wounds were:

- A right forearm superficial abrasion (defensive in nature probably).
- A lateral right flank wound consistent with glancing or ricochet shot.

4.4.4 Cause of Death and Hemorrhagic Shock

Death was caused by hemorrhagic shock from vascular injury and organ laceration. Toxicology for drugs/alcohol was negative. Time of death was from 20:45–21:00 hrs, established by rigor mortis and rate of body cooling [28].

Table 1 Shot Gun Injuries

4.5 Ballistic Confirmation and Weapon

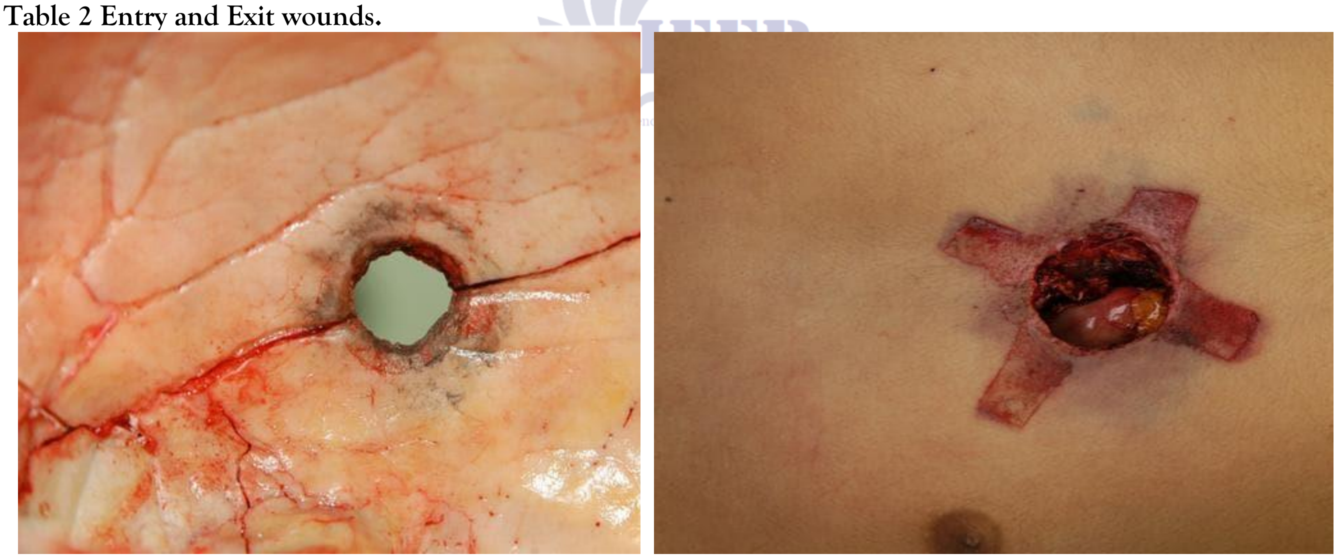
• Range estimation (~17 meters)

PFSA test firings of the alleged pistol simulated the characteristics of the wounds, at a distance of 15 to 20 meters. No stippling and no soot were found, which eliminated close-range firing [24].

• Ammunition Profile Matching

Microscopic comparison showed the same striation marks on the recovered bullet and test rounds fired from the suspect's licensed 9mm Beretta. Cartridge case ejection marks and firing pin impressions were a similar match [25]. This established that the firearm had discharged the lethal bullets.

Table 2 Entry and Exit wounds.



4.6 Forensic Contribution towards Legal Resolution

• Arrest

Based on witness statements and forensic identifications, the suspect was taken into custody two days later. The firearm was found in his residence during a search warrant. His prints were on the casing and magazine.

• Confession and Conviction

Confronted with ballistics reports and forensic data, the suspect admitted upon questioning. He explained that he had fired in anger following a brawl. The PFSA officials on trial testified regarding range estimation and bullet-match findings, and the forensic pathologist testified regarding wound pathologies. The suspect was found guilty under Section 302 PPC with life imprisonment escalated under terrorism provisions due to hazard to public exposure [26].

5. Discussion

5.1 Diagnostic Value of Morphological Markers

Morphological markers including soot, tattooing, abrasion collars, and wound dimensions are valuable in determining the direction and degree of fire. Abrasion collars are most valuable in identifying entry wounds, while soot deposition can be used to quantify firing distance. The presence or absence of these markers is extremely valuable diagnostically, particularly when combined with trajectory analysis. Their unavailability in shots of intermediate to long range also tends to indicate the necessity of alternative approaches like radiologic imaging or histopathology for elucidation [31].

5.2 Limitations in Scene Interpretation

Scene interpretation is subject to environmental and situational influences. Rain or wind can destroy soot marks or bloodstains, and garments can be misleading by concealing or altering the characteristics of wounds. Ricochet wound or bullet fragmentation wounds can be superficially similar to primary entry wounds. Such cases render single dependence on surface morphology inadequate, and lead to serious errors in crime reconstruction, particularly if photographic documentation is poor [32].

5.3 Significance of Radiologic and Histologic Combined Facilities

Postmortem radiology, especially PMCT, is becoming increasingly popular in forensic science because it is non-invasive and highly accurate in localization. It may detect bullet tracks, internal fractures, and foreign objects lodged within the body. On the other hand, MRI can be optimally used for soft-tissue trauma like hemorrhage and vascular injury. However, autopsy is still the gold standard for assessment of soft-tissue trauma, particularly cardiac, liver, and bowel trauma. Histology adds another dimension to aid in determining tissue viability and chronology of injury, for example, to distinguish ante-mortem from post-mortem change [33,34].

5.4 Comparison to Global Case Examples

Forensic examination worldwide more and more depends on the combined methods. Multi-modal use of PMCT, histopathology, and standard autopsy in European and US legal systems has been conspicuous with diagnostics. A Swiss study reported PMCT to be correct in detecting bullet paths in 94% of patients and visualizing cranial fractures missed on autopsy. In the United States too, imaging by radiology proved useful to establish fragmentation of projectiles and exclude exit wounds in initially misclassified cases [35,36].

5.5 Implications for Police, Medico-Legal, and Legal Communities

Forensic departments must be in close contact with police forces from the beginning of an investigation. Training in interpreting soot and abrasion marks and in preserving clothes for laboratory analysis is essential. Meanwhile, medico-legal professionals should incorporate radiologic imaging where available, as it enables virtual tracing of projectile tracks and fracture lines. Forensic scientists are aided by radiologic evidence as it enhances forensic testimony, especially in the explanation of complicated wound dynamics under the courtroom testimony. These combined techniques enhance investigation quality and judicial understanding [37].

5.6 Range Misclassification Traps

Misclassification of shooting ranges is a significant forensic problem. Ricochet wounds or fragment injuries are frequently diagnosed as a direct hit in most cases. Soot can be lost through environmental degradation or hidden by clothing and therefore misleadingly suggest distant-range firing. Likewise, contact wounds on irregular surfaces (i.e., extremities) can be misleading because of irregular abrasion shapes. Without radiologic or histologic context, such misleading interpretation can mislead culpability appraisal, especially in criminal controversies regarding intent or claims of self-defense [38].

5.7 Advantages of the Investigatory Protocol

The forensic sequence outlined here—crime scene mapping, bloodstain pattern analysis, wound morphology, radiologic examination, autopsy, and histopathology—is a sound model. Each technique fills in the gaps of the others: imaging verifies direction and location of foreign bodies, histology separates antemortem from postmortem trauma, and ballistic analysis correlates wounds to one firearm. Utilization of several techniques eliminates diagnostic ambiguity and enhances the credibility of the forensic report, essential for high-profile trial cases [39].

6. Medico-Legal and Criminal Justice Relevance

6.1 Shotgun Injury in Homicide vs. Suicide Determination

Shotgun injuries provide important forensic indicators to separate homicide from suicide. For suicide, the injury would be at reachable locations of the body (e.g., chest, mouth) and would have contact or near-contact discharge patterns. For homicide, the entry wound can be on non-self-inflicted body regions such as the back or back of head. DiMaio is very accurate when explaining that cases of suicide would have nicely grouped pellet impressions and clear muzzle impressions [1]. Combined with the victim's writing hand and psychological state, these telltale signs make intent conclusions stronger.

6.2 Application of Forensic Pathology in Convictions

Forensic pathology serves a critical function in judicial decision-making by mapping external trauma onto internal tracks and tissue reaction. In shotgun homicide, forensic pathologists measure pellet scatter, penetration depth, and related hemorrhage to estimate range and angle. Karger showed how spread patterns within come to represent barrel length and ammunition, useful to courtroom presentation [6]. DiMaio's forensic handbooks note that autopsy and radiologic protocol standards confirm claims of homicide as opposed to accidental or suicidal discharge [7].

6.3 Shotgun Crime Legal Standards of Evidence

Forensic evidence of shotgun firing must be jurisdictionally admissible and valid. The court will typically accept ballistic evidence (e.g., range estimation, pellet analysis) if it passes the Daubert or Frye test, respectively, depending on the jurisdiction. As Heard demonstrates, its impact in court cases depends on reproducibility, consensus among experts, and clarity of methods [2]. Testimony that is admitted is then subject to documentation by proper means, authentication of analysis protocols, and peer-reviewed forensic protocols.

6.4 Range Estimation Admissibility in Court

Range estimation—a critical element of forensic examinations—typically is regarded as expert testimony. Forensic reconstruction of test shot pellet distribution and wound anatomy always determines shooter range. Sellier and Kneubuehl observe that close-range wounds exhibit denser dispersion, deeper penetration, and more tissue damage [4]. Courts likely would accept such a determination scientifically if the method involves standardized controls and concordance with radiologic imaging or autopsy reports.

6.5 Ethical Management of Testimony and Evidence

Professional ethics require forensic experts to offer unbiased results irrespective of legal conclusions. Objective reporting, chain-of-custody integrity, and a robustness to prosecutorial pressure are the focal points stressed by Garrison [18]. Since legal outcomes tend to hinge on forensic determinations, particularly in shotgun cases, the professional obligation of avoiding overstatement and reporting threshold is crucial. Courts have continually underscored the fact that experts' unjustified inference or overstepping can result in wrongful convictions or appeals.

7.Conclusion

The forensic interpretation of 12-gauge shotgun injuries presents a unique set of challenges and opportunities for medicolegal investigations. This case has illustrated how a comprehensive approach—integrating wound morphology, ballistic analysis, radiologic imaging, and autopsy findings—can accurately determine the range, direction, and intent of shotgun discharge. Shotgun wounds vary dramatically with range and ammunition type, and careful attention to validated morphological indicators such as pellet spread, soot deposition, muzzle imprinting, and internal tissue damage is essential for reconstructing the shooting event. Close-range shots often leave tightly clustered pellet wounds, extensive internal cavitation, and pronounced soot and searing, while intermediate- and long-range injuries result in broader dispersal patterns, diminished soot, and distinct abrasion collars. These physical findings, when corroborated with radiological data—particularly through post-mortem CT scans—offer a more nuanced and scientifically grounded estimation of firing distance. Importantly, this case emphasized the medico-legal significance of aligning external injuries with internal wound tracks and blood spatter patterns at the crime scene. When interpreted in conjunction with crime scene reconstruction and forensic ballistics, such alignment not only strengthens the evidentiary narrative but also clarifies legal questions regarding intent, trajectory, and possible self-infliction. The incorporation of forensic pathology in criminal proceedings enhances the objectivity and credibility of expert testimony, particularly when used to rule out suicide, accidental discharge, or distant firing. A central takeaway from this case is the irreplaceable role of autopsy and radiologic imaging in producing reproducible and defensible forensic conclusions. As forensic technology evolves, digital autopsies and 3D reconstruction software are likely to become integral tools for visualizing wound trajectories and internal damage in both teaching and litigation contexts. The future of shotgun forensics lies in interdisciplinary collaboration, data standardization, and enhanced forensic education. Continued research into shotgun-specific wound ballistics will allow forensic professionals to refine distance estimation techniques and reduce the margin for misinterpretation. To further improve forensic outcomes, standardized protocols for crime scene and autopsy procedures are strongly recommended. At the scene, investigators should prioritize preserving clothing, documenting injury patterns with high-resolution photography, mapping bloodstains, and collecting all relevant ballistic evidence, including spent cartridges and wadding. During autopsy, pathologists should conduct full-body radiographic scans before dissection, retrieve all embedded pellets, chart internal damage with precision, and send representative tissue samples for histopathological analysis. These measures help mitigate common pitfalls such as range misclassification and misdiagnosis of wound types. Furthermore, ethical standards must be upheld throughout the investigative process to ensure objectivity, transparency, and adherence to the legal burden of proof. Ultimately, this integrated and meticulous approach ensures that forensic findings withstand legal scrutiny, contribute meaningfully to justice delivery, and protect both victims and defendants from flawed interpretations of complex shotgun injuries.

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