WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Analysis of Terminal Ballistics on Medical Forensics: Criteria and Challenges in the Forensic Area in Brazil

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DOI: https://doi.org/10.55248/gengpi.5.0224.0535

ABSTRACT

Introduction: When there is a suspicion of a crime and there is a need to search for the truth of the facts, forensic experts will be present when called upon by the competent authorities. Criminal experts are responsible for bringing out the truth in various types of crime, through forensic science. Objectives: The aim of this study is to review the literature on the importance of medical forensics and terminal ballistics analysis, given that many cases remain unsolved due to a lack of structure, professional knowledge and investment. Methodology: This article is a systematic review, based on the PRISMA methodology (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), which seeks to identify medical expertise and analysis of terminal ballistics. Results and Discussion: The medical examinations carried out today are inefficient. It is estimated that out of every 10 forensic examinations carried out, 4 to 5 have substantial problems (which sometimes render them useless) because the first police authority did not know how to call in the competent expert, or point out their real needs for the investigation. Final considerations: Medical expertise in Brazil, associated with forensic knowledge and interconnected with terminal ballistics, needs professionals with greater knowledge and more advanced and modern investigation structures.

Keywords: Medical Forensics, Terminal Ballistics, Forensic Medicine.

INTRODUCTION

According to the Brazilian Secretariat of Public Security and Ministry of Defense, there were 61,726 violent deaths in Brazil in 2022 alone. There were 20.11 deaths for every 100,000 inhabitants, with data referring to homicides, robberies and serious bodily injury followed by death. Current figures for 2023 show an increase of 8% on the previous year (IPEA, 2023).

According to data released by UNODC (UN Office on Drugs and Crime), the countries with the highest rates of violence are mainly located in Africa and South and Central America. As a rule, the most violent countries have a low human development index (HDI) (UNODC, 2023).

The relationship between a low HDI index and greater violence or a high HDI index and less violence is well-established and can be an excellent clue for public crime prevention policies. Brazil, which until recently occupied 20th place in the ranking of the most violent countries, has now slipped to 18th place (2022). Soon (if killings continue at the current rate) we will be among the 10 most violent countries on the planet.

The percentage of murders using firearms reached the highest level ever recorded in the country and reached 72.4% of the country's homicides in 2022. The data comes from the Atlas of Violence, released today by IPEA (Institute for Applied Economic Research) and the Brazilian Public Security Forum, which uses figures from the Ministry of Health's SIM (Mortality Information System).

In all, 47,500 people were murdered by firearms in 2022, the highest absolute number recorded in the history of Brazilian homicide data/SIM has provided information on lethality since 1980, when the rate of violent deaths by firearms was only 43.9%. In 2023, the state of São Paulo registered a firearm rate of 54.4% of murders, while only Roraima and Amapá had lower rates: 37.5% and 46.2% respectively (Cerqueira et al., 2023).

Brazil also has another alarming rate. According to the latest report from the National Strategy for Justice and Public Security, 51% of homicides in Brazil are committed by illegal firearms (Gomes et.al, 2023).

In 2023, Brazil recorded 28,200 intentional homicides, but what is most frightening is the punishment for these crimes. According to the data, only 6% of intentional homicides are solved in the country (Cerqueira et al., 2023).

There is a lot to be explored within terminal ballistics, an area whose potential involves collaborating with Brazil's public security and, consequently, improving it.

Terminal ballistics is the study of the interaction between the various types of firearm projectiles (FPP) and their targets, which are classified as hard or soft, depending on their resistance to penetration due to the presence or absence of armor or bulkhead.

Terminal ballistics can also be called effects ballistics or wound ballistics, whose basic principle is to study the effects produced by the PAF from when it leaves the mouth of the firearm barrel until it hits the target, be it a human being, animal or physical and inanimate structure (Tocchetto, 2020).

This knowledge is of fundamental importance for investigating crimes, promoting peace, justice and effective institutions, which is one of the thematic fields still little known by Forensic Medicine in Brazil.

The aim of this study is to review the literature on the importance of medical forensics and terminal ballistics analysis, given that many cases remain unsolved due to a lack of structure, professional knowledge and investment.

Methods

This article is a systematic review, based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology, which seeks to identify medical expertise and analysis of terminal ballistics.

The search descriptors were selected from the Descriptors in Health Sciences (DeCS) website and then combined with the Boolean operator "AND". The databases used for the search were PubMed and the Virtual Health Library (VHL), which evaluated cross-sectional, cohort and case-control studies from 2017 to 2024 in Portuguese, English and Spanish.

In all, the result of the search in the databases using the descriptors, but without the application of filters, resulted in 221 articles available. After applying the following filters, PubMed: search periods between 2017 and 2024, Portuguese, English and Spanish language and type of literature being a cross-sectional study. VHL: search periods between 2017 and 2024, Portuguese, English, Spanish language and type of literature being an observational study, a total of 65 articles were selected.

After pre-selecting the articles, a research protocol was created, which clearly illustrated the objective of the study, the data collection process and the criteria involved in including the articles. After the analysis, 42 studies were excluded. Therefore, 16 articles were selected for this review.

Results and Discussion

Targets and projectiles (Impact Power)

Hard targets can range from tank armor to bulletproof vests. To neutralize them there are various types of ammunition, from projectiles called APDS or APFDS, which due to their high density combined with a small cross-sectional area achieve good perforation, to focal charges, such as RPGs, for example, which use a cone-shaped explosive charge that, when it hits the target, projects the explosion to a single point, achieving high temperatures at a high impact velocity.

Soft targets are considered to be animals as well as humans (Svecova et al., 2018).

In the context of terminal ballistics, the energies involved when a PAF hits the target are called: 1) IMPACT ENERGY (EI), referring to the remaining energy of the projectile at the instant it comes into contact with the target; 2) EMERGING ENERGY (EE), referring to the kinetic energy with which the PAF emerges from the target when it has completely crossed it; and 3) TRANSFERRED ENERGY (ET), referring to the difference between EI and EE (when a PAF remains inside the target and therefore cannot cross it, ET = EI) (Tocchetto, 2020).

The aim is always for the ET to be as high as possible so that the projectiles never emerge or, if they do emerge, do so carrying the minimum kinetic energy (Gomes et.al, 2023).

The term "IMPACT POWER" (IP) is used to refer to the space or depth of the wound produced after the target is hit. In this context, there is a large IP when, despite a large IS, the wound has only a small depth. High PI values are said to cause shock states, and this term designates a complex set of physiological effects that tend to incapacitate the affected individual (or animal) very quickly (Tocchetto, 2020).

In order to incapacitate a target, the determining factors are: 1) the location and direction of the wound; 2) the impact speed; 3) the energy density (in J/mm2 when you want to know the piercing capacity); 4) the design of the ammunition tip; 5) the stability of the PAF after impact; and finally 6) the stability of the shape of the PAF throughout the piercing of the target.

Still on this last factor, we must remember the temporary cavity, which is a kind of shock wave that forms around the path traveled by the projectile (formed mainly by high-energy PAF) and which tends to seek normality after expansion, forming, in the end, the so-called permanent cavity. In other words, the size of the cavity formed is proportional to the speed of the PAF, and there may be distant injuries to organs not pierced by the projectile, but which have been compressed in the expansion of the temporary cavity (Krasilshchikov et al., 2017).

Forensics and Legal Medicine in Brazil (Brief History)

Forensic expertise in Brazil is intertwined with the very history of law in the country, since it was already provided for in the ordinances that inspired our codes. For this reason, this study will deal in more detail with forensic medical expertise, which is, after all, at the heart of this discussion. This, in turn, is closely related to the history of Forensic Medicine in Brazil, as described below (CONTE et.al, 2020).

Santos (2020) points out that, due to its pioneering spirit, the main influence of Brazilian Forensic Medicine in its origins was French, with German, Italian and Portuguese influences also standing out.

Its nationalization began around 1860, with the first course in forensic

forensic thanatology in Brazil in Rio de Janeiro, taking shape in Bahia around two decades later, with Raimundo Nina Rodrigues, who began forensic medical research based on the Brazilian reality (CONTE et.al, 2020).

After this period, one of the greatest exponents of the specialty to this day emerged, Oscar Freire de Carvalho, who came to São Paulo from Bahia in 1913 and was invited by Arnaldo Vieira de Carvalho to lead the chair of Forensic Medicine at the newly created Faculty of Medicine and Surgery of São Paulo, which would later become part of the University of São Paulo. The building that initially housed the Chair of Anatomy, led by Alfonso Bovero, would years later become home to the Institute of Forensic Medicine, from 1922, today called the Oscar Freire Institute, which is currently part of the Department of Forensic Medicine, Medical Ethics and Social and Occupational Medicine at the University of São Paulo (BITTAR, 2023).

In the field of law, in 1832, the then "Code of Criminal Procedure" established official forensic examinations in Brazil (BITTAR, 2023).

That same year, Forensic Medicine became a compulsory subject in some medical and law schools, and many of the provisions of the old 1832 code were merely adapted over the years and are still in force in the current Code of Criminal Procedure.

However, forensic medicine was only regulated in 1854, by Decree No. 1.740 of that year, when the "Medico-Legal Advisory Office" was created at the then Police Department of the Court, which was responsible for carrying out "forensic examinations and any other examinations necessary for the investigation of crimes and suspected facts" (BITTAR, 2023).

Even so, forensic medicine was only included as a subject in law courses in 1891, following a proposal by then deputy Rui Barbosa (BITTAR, 2023).

Currently, forensic medical practice in Brazil is an official and public activity, with Forensic Medical Institutes all over the country, with a central office in each of the state capitals, as well as the Federal District. The report, therefore, can be considered an administrative act, and has the value of an official document, which will be discussed in more detail below, with regard to the benefits and detriments this entails.

Current reality of forensic medical examinations in Brazil

Tattoli (2019) describes that in order to understand the existing problems in the use of expert reports in the current legal system, it is essential to analyze the functioning of the forensic police, its structure and its system for preparing reports.

Based on this premise, as a sample, the findings can reflect the

successes and failures that can be seen nationwide. Furthermore, even though the data collected is mostly focused on the local level, the conclusions certainly apply not only to Brazil, but are also relevant to similar practices found in foreign legal systems, especially those rooted in Civil Law, as the conclusions of this study will demonstrate.Problems arising from the delegation of responsibilities (DE SÁ et.al, 2022).

According to García Mina et.al (2022), in most of today's legal systems, regardless of the local legal tradition, it is common sense that when a crime occurs or there is an occurrence that results in harm to a person, including death, the police force needs to be completely on the scene, including the expert, the investigator and overt policing to ensure the proper isolation of the area.

According to Bittar (2023), in the state of São Paulo, for example, there are often "disagreements" between police forces, who argue among themselves about the powers of security agents, and even health agents, to carry out certain functions. As an illustration of this problem, there has recently been a fervent discussion about the competence to attend to victims, due to the need to preserve the scenes of possible crimes, which led to the publication of a controversial resolution by the Public Security Secretariat.

The resolution, published after evidence of crimes allegedly committed by police authorities (possibly in retaliation for the actions of criminal factions), prohibited police officers from attending to victims of serious bodily injury, homicide, attempted homicide, robbery and extortion by kidnapping resulting in death. It was therefore determined that the competence to deal with these the Mobile Emergency Assistance Service - SAMU,

since, according to the text of the resolution, it would have "a protocol for dealing with incidents with signs of crime in order to preserve expert evidence". It is assumed the executive understood that military police and other police officers could jeopardize the evidence indispensable to forensics (BITTAR, 2023).

According to Watanabe (2021), this is a serious problem of a lack of professionals prepared to facilitate, or even enable, a well-done forensic investigation. After all, in addition to police officers being notoriously considered suspects of hindering forensics, this same resolution is contradictory, as it states in its article that "the Superintendence of the Technical Scientific Police, becoming aware, by any means, of the crimes mentioned in article 1 of this resolution, will immediately move a specialized team to the scene, which will await the presence of the Police Authority or its request for the work to begin".

For Lima Neto (2020) it is surprising, to say the least, that a team appointed by the superintendence of the scientific police does not have a member with "police authority" to begin its work. This text clearly shows that there is a lack of professionals, training or both. Whether due to a lack of training of experts or a lack of funds, this situation is unacceptable in a modern, minimally organized legal system, which should be balanced in its efficiency and especially in issues that are so fundamental and intrinsic to the criminal process.

A reflection of this serious problem is the fact that the technique and system of forensic examinations carried out today are inefficient. It is estimated that out of every 10 forensic examinations carried out, 4 to 5 have substantial problems (which sometimes render them useless) because the first police authority did not know how to call in the competent expert, or point out their real needs for the investigation (LEMOS, 2020).

According to Makboula Bou Ali et.al (2023), forensics is fundamental to criminal investigation and the production of the most relevant evidence for the smooth running of criminal proceedings, and this fact alone justifies the importance of this study. After all, within the Brazilian legal system, the official body responsible for carrying out forensic medical examinations are the scientific police forces of each state in the federation.

Competences and Obligations of the Forensic Medical Institute

Among the competencies and obligations of the Forensic Medical Institute today is the function of developing research in the field of Forensic Medicine, with a view to improving techniques and creating new working methods based on technological and scientific development. It is also up to the Forensic Medical Institute to promote studies and the respective dissemination of technical and scientific works relating to the areas of Forensic Medicine (VERMEIJ, E., RIJNDERS, M., PIEPER, P., & HERMSEN, R. (2018).

According to Watanabe (2021), the Forensic Medical Institute is responsible for carrying out examinations on living individuals for bodily injury, sexology, physical health, age verification, verification of drunkenness and radiological examinations to elucidate coroners' diagnoses. The Forensic Medical Institute is also responsible for carrying out tests and investigations on toxic products, organic liquids, viscera, food and other substances, although the latter can sometimes also be carried out by the Criminalistics Institute, depending on the case.

With regard to corpses, the Forensic Medical Institute is responsible for carrying out necroscopic examinations, exhumations, anthropological examinations and the like. It is also responsible for examining the biological material of victims, taking photographs of people, parts and instruments related to the examination, as well as carrying out examinations and research in the field of forensic odontology (BITTAR, 2023).

According to Makboula Bou Ali et.al (2023), although this function is not known to the general public, it is also the responsibility of the Forensic Medical Institute to carry out psychological assessments of victims in order to conclude investigations and to provide social assistance to relatives and victims. Finally, as a general function, the Forensic Medical Institute is responsible for issuing technical expert reports pertinent to its area of activity, in compliance with the legislation in force.

Clearly, these duties require a large number of professionals, most of whom are qualified. As in other areas, the public administration has difficulties in filling these gaps, and needs to respond to the existing demand. In this process, improvised mechanisms emerge, which sometimes don't work as they should or as expected (BITTAR, 2023).

Brazil, which has been growing rapidly for decades, suffers from excess demand in various types of fundamental services. This problem applies to the Forensic Medical Institute and, as with many other services, solutions have been studied over the years to increase demand (LEMOS, 2020).

One of the solutions put into practice were delegations to city halls to carry out simplified examinations on corpses, especially in cases where examination by the Forensic Medical Institute was not mandatory (although sometimes necessary). This decentralization, visibly contrary to any search for excellence in the service, occurred, for example, in the capital and in several other cities in the state of São Paulo (LEMOS, 2020).

A large part of the population is repeatedly confused about the differentiation between the work of the Forensic Medical Institute and the death verification services (known by the acronym "SVO"). This differentiation is of fundamental importance and relevance to this study (BITTAR, 2023).

SVOs are units maintained by city halls for simple death confirmation and macroscopic verification, indicating the most likely cause of death, without the rigor and precision of an autopsy. After all, unlike the SVO, it uses pathological anatomy and other forensic medicine resources, such as toxicological dosages, among others (BITTAR, 2023).

The function of the SVO, therefore, is not to carry out complete, much less complex, investigations. To the detriment of precision, they are a faster way of providing the document known as a "death certificate", which is necessary for the burial of corpses (LEMOS, 2020).

According to Lemos (2020), although the documents issued by the SVO must be signed by a doctor, they do not necessarily have to be examined by a legally qualified expert. However, due to the significant number of deaths and other occurrences, the SVOs sometimes end up, so to speak, replacing the Forensic Medical Institute in cases that would often fall under the exclusive competence (in theory, obligation) of the Forensic Medical Institute.

Bittar (2023) cites that a clear example of this is in relation to deaths that have not been clarified, even by indications. In these cases, the corpses must be examined. However, whether due to a lack of structure or qualified personnel, or perhaps even due to parties interested in not carrying out the examination, based on the cause of death presented in a particular report issued by the SVO, a clearly unexplained death is "camouflaged" as being known, and the examination, which could prove decisive in a legal case, is not carried out.

Lemos (2020) states that it is clear that there are cases of unexplained deaths in which neither the Medico-Legal Institutes nor the SVOs carry out any kind of examination or necropsy. In these cases, as a rule, the family resorts to a death certificate issued by a private doctor who, to avoid further suffering in the face of the loss, issues it indicating the most likely cause of death. However, if this is not done with the necessary rigor and only in cases where the law allows it, this professional can be punished in the criminal spheres and by the professional ethics courts provided for by law. However, this type of ascertainment of cause of death does not need to be highlighted, as it is a one-off matter, and the focus of this study is not to discuss isolated acts by doctors, but rather the system in which forensic medical examinations are inserted as a whole.

According to Makboula Bou Ali et.al (2023), there is a need to improve the instruments available, using convergence between information, the appropriate use of funds in the sector, better qualification and remuneration of professionals, among many other factors which, although they also depend on a certain technological advance.

Terminal ballistics

Ballistics is a fundamental area of knowledge for the police service because, on the one hand, the police need to shoot firearms and, on the other hand, they are sometimes attacked by firearms (SANTOS, 2022).

Nowadays, in the world of shooting, terminal ballistics is once again a subject of recurring evidence, a subject discussed by police professionals, shooters, instructors and technicians in the field (AMORIM JÚNIOR & CAROLINA RUSSO, 2021).

Ballistics is a scientific field that studies "all the processes related to the movement of a projectile". It is divided into four branches: internal ballistics, transitional ballistics, external ballistics and, finally, terminal ballistics. Internal ballistics comprises the "process of ignition of the propellant, the burning of the propellant in the chamber, the pressurization of the chamber, the first movement of the projectile, (...) and obturation of the chamber, the internal dynamics of the projectile, and the dynamics of the barrel during the fire cycle" (LISBOA, 2023).

According to Mendonça & De Oliveira Mendes (2023), terminal ballistics refers to the phenomena that occur inside a firearm, from the moment the striker hits the fulminating capsule to the moment the projectile leaves the barrel of the weapon (FIGURE 1). On the other hand, transitional ballistics encompasses the period when the projectile begins its movement outside the gun, but is still influenced by the gases coming out of the barrel.

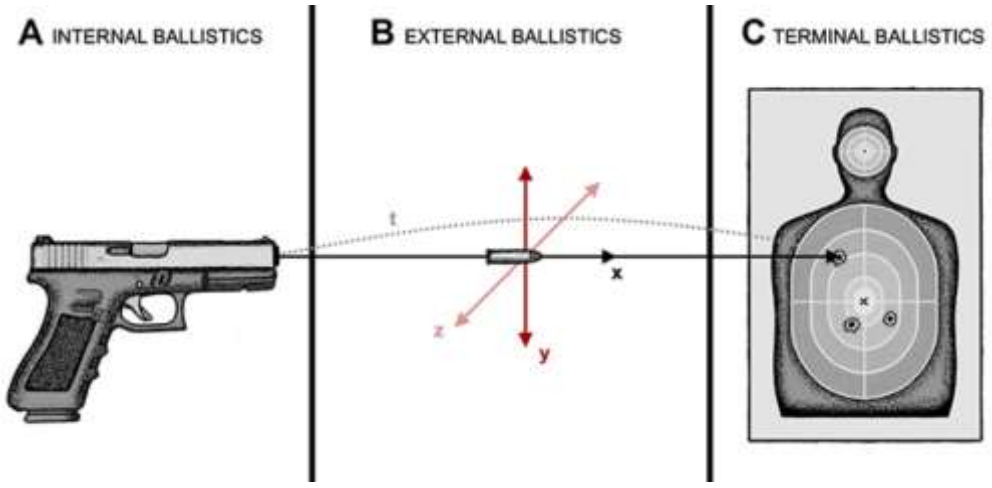

Figure 1. Phases of ballistics. Notes: (A) Internal ballistics occurs inside the firearm. (B) External ballistics describes the period that occurs after the projectile leaves the firearm and before it hits the target. The trajectory of the projectile (t) can vary along the direction of its flight path (x) if the nose of

the bullet deviates on its vertical axis, which is known as pitch (y), or on the horizontal axis, known as yaw (z). (C) Terminal or wound ballistics describes the effect of the projectile after it hits a target or victim. Source:dovepress.com/gunshot-wounds-ballistics-pathology-and-treatment-recommendations-with-peer-reviewed-fulltext-article-ORR (2023).

Projectiles popularly known as "bullets" are available in a wide variety and differ in terms of material, size, shape and other design aspects that affect flight behavior, yaw, impact coefficient (KE) on the target and penetration capacity and injury potential (FIGURE 2). Projectiles are mainly composed of lead due to their high density, mass and therefore KE, although when fired at more than 2,000 ft/s, the high temperature of the barrel can cause it to deform. To mitigate temperature-induced deformation, projectiles are usually produced with lead alloys or coated with a copper or copper alloy jacket (FALARZ, 2020).

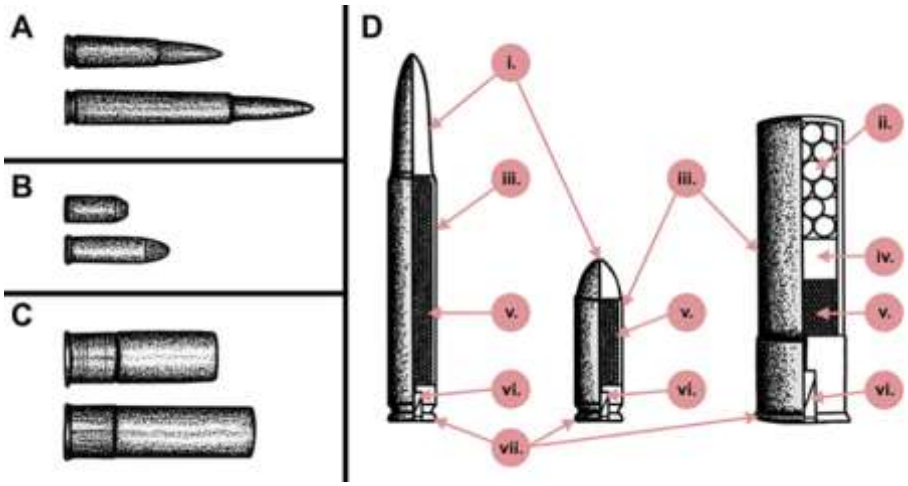

Figure 2. Anatomy of ammunition. Notes: Simplified sketches showing the general appearance of different types of ammunition, cartridges, ammunition or cartridges. (A) High-velocity/energy cartridges, normally fired by rifles, are designed for long-distance use in hunting or armed conflict. (B) Low-velocity/energy cartridges, normally used in firearms. The drawings show an ammunition with a hollow point and another with a round point. (C) Rifle ammunition, normally used in short-barrelled rifles, designed for short-range targets. (D) Ammunition is generally made up of the following elements (i) Bullet (projectile); (iii) Casing; (v) Propellant; (vi) Primer; (vii) Rim.Rifle cartridges contain ii) Pellets (projectiles) and iv) Casing. Source:dovepress.com/gunshot-wounds-ballistics-pathology-and-treatment-recommendations-with-peer-reviewed-fulltext-article-ORR (2023).

External ballistics (FIGURE 3), on the other hand, covers the period in which the projectile is no longer under the influence of the gases at the muzzle and moves through the air until the moment just before impact with the target. This branch of ballistics studies the velocity of the projectile, the rate of rotation, the physical properties (distribution of mass and weight), the dynamics and stability of the projectile, the expected trajectory of the projectile, the time of flight of the projectile and the angle (AMORIM JÚNIOR & CAROLINA RUSSO, 2021).

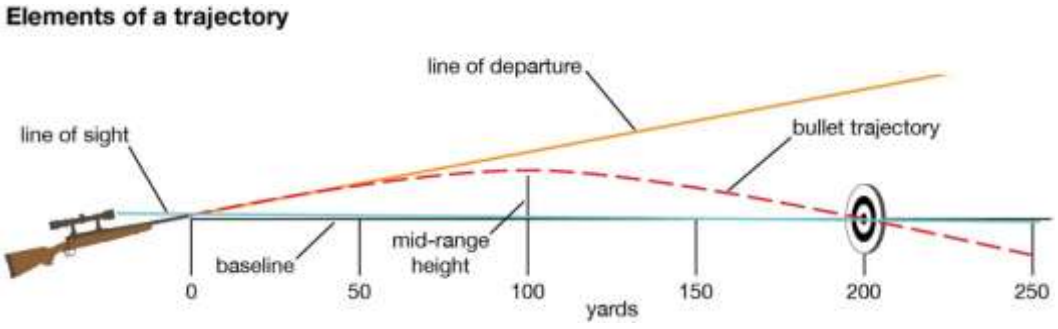

Figure 3 - Elements of the trajectory. The illustration above shows how the projectile moves according to power (firing energy), weight and distance from the target. Source:rifleshootermag.com/editorial/ballistics-for-dummies/83897 (2023).

The distance between a firearm and its target, as well as the initial velocity of the projectile, play a significant role in the potential for injury (FIGURE 4). High-velocity weapons retain a significant amount of KE at close range, while low-velocity projectiles quickly lose substantial energy. However, at close range, both high- and low-velocity projectiles can retain a high percentage of their KE (AMORIM JÚNIOR & CAROLINA RUSSO, 2021).

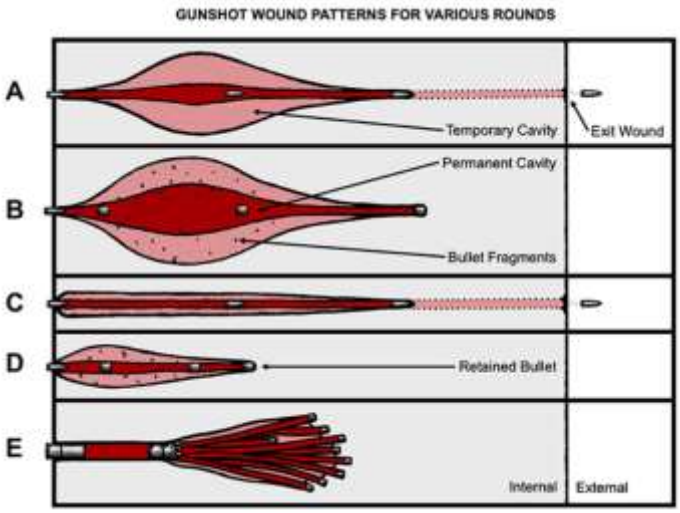

Figure 4: Wound patterns for various projectiles. Notes: Simplified sketches showing typical patterns of internal wounds caused by commonly used projectile classes. The permanent cavity and temporary cavity of each wound are shown in red and pink respectively. Non-deforming projectiles (A and C) can be retained or exit the body. While deforming ammunition (B, D and E) can exit the body, they are more likely to be retained. (A) High-energy wound from a non-deforming bullet. (B) High-energy wound from a deforming bullet. (C) Low-energy wound from a non-deforming bullet. (D) Low-energy wound from a deforming bullet. (E) Low-energy wound from a shotgun shell (deforming bullet). Source: dovepress.com/gunshot-wounds-ballistics-pathology-and-treatment-recommendations-with-peer-reviewed-fulltext-article-ORR (2023).

Projectile pathology

While the KE transferred at the moment of impact determines the penetration capacity, the injury potential depends on the structures hit by the projectile. Gunshot wounds usually result in diffuse soft tissue damage, volumetric muscle loss, hemorrhage, fracture and severe pain. Tissue structure varies according to specific gravity or density and elasticity, which contribute to the potential for injury, causing inconsistent energy dissipation and tissue rupture along the bullet's path (AMORIM JÚNIOR & CAROLINA RUSSO, 2021).

When a projectile enters the skin, the tissue accelerates radially and is displaced centrifugally. The size of the entry wound is transiently larger than the caliber, but normally the defect reversibly contracts to a diameter smaller than the cross-sectional area of the bullet due to the highly elastic properties of the skin (FIGURE 5). In addition, entry wound defects can differ depending on the shape of the bullet involved. The effects of penetration are further complicated by the presence of intermediate targets, such as clothing, glass or wood, which can alter the shape, fragmentation or trajectory of the projectile (LEMOS, 2020).

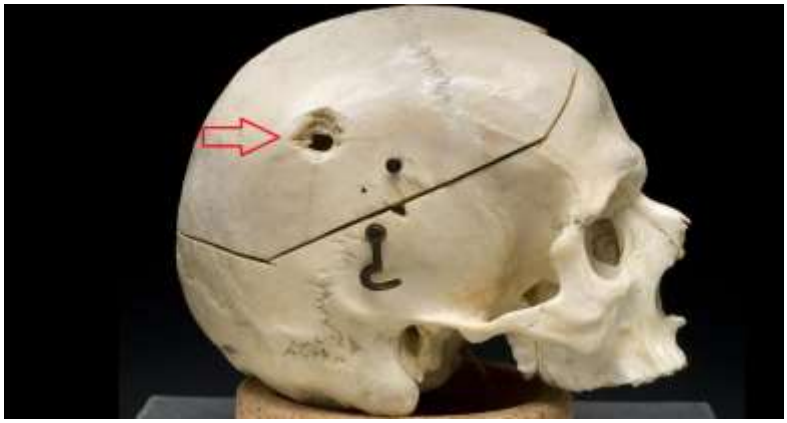

Figure 5 - Example of projectile perforation of the skull. Source:rifleshootermag.com/editorial/ballistics-for-dummies/83897 (2023).

Serious damage possible

External bleeding (exsanguination)

Puncture by a firearm can, among other injuries, cause external bleeding. This is usually due to the projectile grazing the victim, but with enough force to cause some damage to vascularized areas, thus causing external bleeding which, if not promptly treated, can cause death (LEMOS, 2020).

Muscle trauma

Muscle trauma occurs when the shot ends up tearing muscles, which can cause serious problems such as muscle malfunction, which may require surgical procedures to reconstruct the broken tissue. In addition to long periods of physiotherapy if necessary for muscle rehabilitation (LEMOS, 2020).

Internal bleeding

Internal bleeding occurs when the projectile pierces a vital area of the patient, causing excessive "leakage" of blood. This leakage comes from an artery, vein or even the perforation of an internal organ (LEMOS, 2020).

Fractures

Fractures can occur when the projectile hits a bone, which can cause more serious damage if the bone in question is close to vital areas (such as the vertebrae or ribs). Even when wearing a ballistic vest, the impact of a projectile can cause fractures (LEMOS, 2020).

Wound structure and forensic medicine

Entry orifice

According to Lisboa (2023), the entry hole is where the projectile enters the victim's body, causing a laceration that leaves clear marks on the skin:

- ✓ Usually round in shape (varying from caliber to caliber);
- ✓ Diameter smaller than the size of the projectile;
- ✓ Irregular edges;
- ✓ Generates a "tunnel" inside the victim called an "equimotic rim".

Figure 6. Different patterns of shots marked on bones. Source:rifleshootermag.com/editorial/ballistics-for-dummies/83897 (2023).

Exit orifice

The exit hole is the place where the projectile exits the victim's body. If it doesn't exist, it is possible that the projectile is lodged inside the victim's body (LISBOA, 2023). The exit holes usually have the following characteristics:

- ✓ Usually irregularly shaped;
- ✓ Diameter larger than the size of the entrance hole;
- ✓ More bleeding than the entrance hole;
- ✓ Edges inverted inwards.

Types of projectiles

There are several types of lethal projectiles for weapons (TABLE 1), each type ends up causing specific damage, thus facilitating the work of the forensic doctor in determining the types of projectiles used in the act of the crime (FIGURE 7), among them are:

TABLE 1. TYPES OF PROJECTILES

Projectile type	Utilization
Ogival	It is the most common, being used for military, police and defense purposes
Sing-along	Used specifically for target shooting
Semi-canto-vivo	General use for defense, hunting and target shooting
Truncated ogival	Also for general use, very popular with practical shooters Very restricted use
Conical	Use for hunting helps to expand the projectile when it hits the target, causing serious and painful wounds and increasing bleeding.
Hollow tip	Use for self-defense, constructed of a core covered by an outer layer
Chamfered	called a shirt or jacket

Source: Lisboa (2023).

Figure 7. Types of projectiles. Source: rifleshootermag.com/editorial/ballistics-for-dummies/83897 (2023).

Caliber

There are several types of caliber and their ballistics vary between them;

TABLE 2 Types of Caliber

Caliber	Weapons	Forensic ballistics
9 mm	Pistols and revolvers	In general, 9mm shots leave a similar entrance and exit hole, and when they pass through the fabric they don't expand much, thus not leaving the "tunnel effect".
30 mm	Pistols and submachine guns	30 mm shots also leave similar entry and exit holes, but cause the "tunnel" effect which causes greater internal bleeding.
45 mm	Rifles and machine guns	45 mm shots cause a clearer "tunnel" effect, thus causing a regular entrance hole but a huge exit hole.
.45	Pistols	.45 shots cause a similar effect to 30mm shots, leaving similar entry and exit holes but with a large internal "tunnel" effect.
.50	Rifles	.50 shots have a similar effect to 45 mm shots, but unlike 45 mm shots, .50 shots leave a large entrance hole and an even larger exit hole, leaving severe damage that causes a lot of bleeding.
Caliber 12	Scopes	12-gauge shot leaves a huge entry hole and as the projectile expands, it ends up leaving several small exit holes and/or leaves shrapnel lodged inside the victim's body.

Source: Lisboa (2023).

FINAL CONSIDERATIONS

First of all, it should be pointed out that at the end of the research it was noted that this study touched on various areas of knowledge. In addition to Law and Medicine, which were obviously its main focuses, the theme has also had a marked impact on History, as well as Biology, Physics and Chemistry, among others. The conclusions drawn from these discussions, although aimed at the first two main areas, may encourage progress in the others.

Since all these areas are linked to forensic medical expertise, it is almost inconceivable that progress in one of them would not interfere with the others, since they are transdisciplinary and interdisciplinary. In this sense, history has shown that, although innovations in just one of them do not immediately impact on the others (as is the case with advances in technology that enable better measurements), at some point they have to be rethought.

The difference between the legal systems is currently a question of speed. After all, new technologies are almost immediately accepted in some legal systems (such as the US, as long as they meet the requirements of acceptance tests). However, it takes far too long for them to be applied systematically in others, such as Brazil.

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