European Journal of Medical and Health Sciences
Vol 6 | Issue 5 | October 2024
ISSN 2593-8339

CASE STUDY

Determination of the Perpetrator-Victim Position in a Case of Severe Traumatic Brain Injury due to a Less-Lethal Weapon Projectile, Based on Brain Injuries

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ABSTRACT

Less-lethal (or non-lethal) weapons cause lethal and non-lethal injuries; this depends on many factors, including the shot distance and the modifications made to the operation of the weapon and the projectiles. This type of weapon has a similar shape to a firearm, shares the same physical and chemical operating principle and uses the combustion of a chemical substance to eject the projectile. In technical terms, the only difference is the projectile. Currently with the changes in weapons and projectiles, it is difficult to make a correlation. Just like lethal firearm projectiles and due to their operation, they leave macroscopic gunshot residues such as powder tattooing or soot deposition, only occasionally a contusion ring. In addition, there is a variety in the appearance of the entrance wounds. Therefore, it is very important to process the scene and carefully dissect the external wound and the surrounding area and, if possible, the recovery of the projectile. We present a case where a non-penetrating superficial injury to the skull produced trauma consistent with a coup contrecoup brain injury, which allows us to identify the perpetrator-victim position.

Keywords: Less-lethal weapons, non-ballistic wounding, traumatic brain injury, unusual firearms.

Submitted: June 18, 2024

Published: October 22, 2024

10.24018/ejmed.2024.6.5.2157

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1. Introduction

For the Colombian state, a traumatic weapon is defined as a "less lethal device, which uses the force created by the expansion of the gases produced by the combustion of a chemical substance to eject a rubber projectile" [1]. Its carrying is restricted, and it is only allowed in special cases [1]. A lethal firearm projectile wound penetrating the skull leaves macroscopic gunshot residue, such as powder tattooing or soot deposition if the shot distance is close or leaves a contusion ring if the distance is further away. It also produces bone fractures with particular characteristics, such as the internal crater and lacerations or perforations in the meninges and a hemorrhagic pathway in the brain tissue; a variant would be the tangential shots that, although they are not penetrating, produce internal manifestations such as contusions and localized subarachnoid hemorrhage. In medico-legal autopsies made in the National Institute of Legal Medicine and Forensic Sciences in the city of Cali, it has been observed that in some cases, the rubber projectile has fragmented into very soft parts that resemble wet cardboard, from which we infer that this is due to the type of alterations made to both the projectile and the weapon. In the present case, the traumatic projectile lacerated the scalp and the aponeurotic galea without fracturing the cranial vault. Internally, there are injuries consistent with contusions and subarachnoid hemorrhage located in a coup contrecoup brain injury, which allows us to infer the position of the perpetrator with respect to the victim.

2. Case Report

A 22-year-old man who, in the context of a fight, was attacked with a less-lethal weapon and was later attacked with a sharp-edged weapon, receiving a lethal heart injury

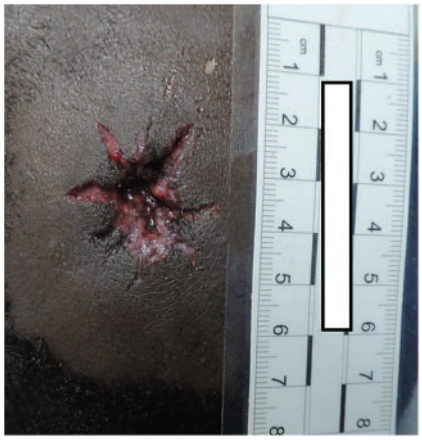

Fig. 1. Stellate entrance wound in the scalp of the left fronto-parietal region.

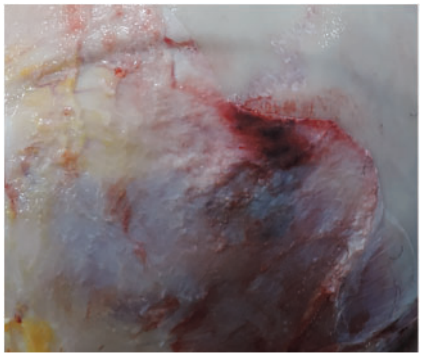

Fig. 2. Subgaleal haematoma in the left fronto-parietal region.

Fig. 3. Coup contusions in the brain at the site of impact.

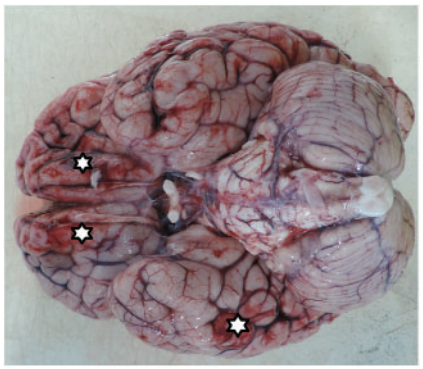

Fig. 4. The white stars show contrecoup contusions in the brain opposite to the point of impact.

and dying of massive hemorrhage. The autopsy findings are conclusive that the victim received a low-fatality weapon projectile wound to the scalp of the left parietal region at a short distance that caused a severe and disabling traumatic brain injury. The entrance wound is a stellate shape without gunshot residue (Fig. 1). The internal examination showed a subgaleal hematoma below the entrance wound, there were no fractures in the cranial vault (Fig. 2). Internally, an area of contusion was observed in the left parietal lobe surrounded by a diffuse subarachnoid hemorrhage that extended to the left frontal and occipital lobes (Fig. 3), in addition, areas of diffuse subarachnoid hemorrhage were observed in the basal gyrus of the right temporal lobes, frontal lobes and an area of focal subarachnoid hemorrhage on the underside of the left temporal lobe (Fig. 4), there were no subdural or epidural collections. In Fig. 5, a reconstruction of the ballistic trajectory is made in relation to the perpetrator-victim position based on the necropsy findings. A stabbing wound was observed in the thorax, penetrating the cavity that perforated the pericardium and left ventricle, resulting in a massive hemorrhage and exsanguination. With the autopsy findings, it is concluded that the individual died of a massive hemorrhage secondary to perforation of the heart by a sharp-edged weapon with a previous disabling traumatic brain injury due to a projectile from a less-lethal weapon that left him defenseless. The urine screening drug test was positive for cocaine, and the sample was sent to toxicology for confirmation of results; blood was also collected from the peripheral vessel for Blood Alcohol Content.

3. Comments

The traumatic brain injury generated by a projectile fired from a non-penetrating, less-lethal weapon causes a brain injury through a combination of contact and acceleration/deceleration forces; when the projectile impacts the head, shock waves are generated from the point of collision and travels rapidly through the bone and brain creating additional tissue stresses, the impact creates a to-and-fro movement in the head so the resulting traumatic brain injury is caused by the forces transmitted by translation, rotation and angulation. Tension causes injury to the brain by contact or inertia. Contrecoup injuries can be caused by acceleration/deceleration of the head alone. The direct impact generates a focal injury, and the movements of the head produce an indirect contusion in the brain at the opposite to the point of impact [2]–[7].

Brain injuries caused by blunt force trauma and, in general, in a traffic accident or from a fall from a height, exhibit a coup and contrecoup injury that allows us to infer the zone of primary impact, unlike injuries produced by the impact of a firearm projectile, when penetrating the skull, generates a hemorrhagic and contusive path accompanied by a subarachnoid hemorrhage and a subdural hematoma if the cerebral vasculature is compromised. In the case of

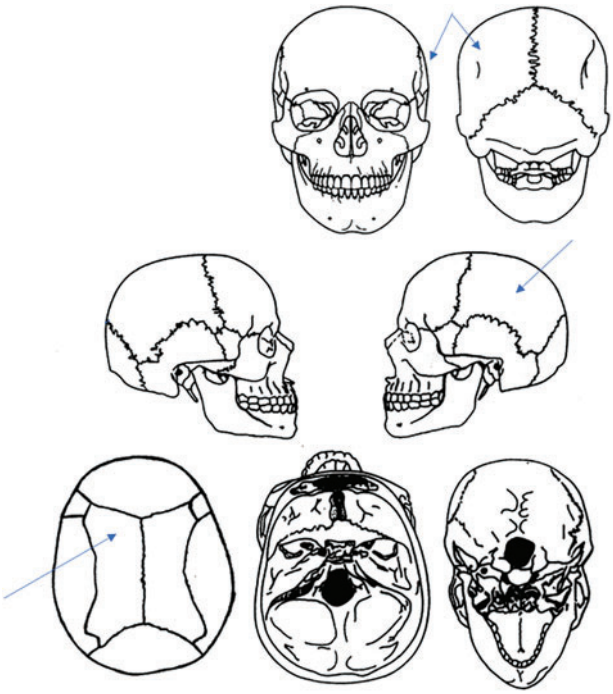

Fig. 5. Schematic representation of the projectile trajectory in three directions along the main axis of the body as observed in the brain. The top row indicates a superior-inferior trajectory, the middle row indicates a posterior-anterior trajectory, and the bottom row indicates a left-right trajectory.

traumatic brain injury caused by a projectile from a less-lethal weapon, the deceleration of the projectile occurs on the bone table, which generates an effect of cerebral acceleration, which decelerates contralateral to the initial impact. This is known as the mechanism of coup and contrecoup. The observation of this pattern of injury and for this case allows us to infer the location of the aggressor when shooting the weapon against the victim's head [2], [4], [8], [9].

The ballistic reconstruction of the perpetrator-victim position by the Ballistic Expert in a penetrating wound to any body cavity is based on the anatomical trajectory described by the coroner in his expert report [8], [10]–[12], which is complemented by the trajectory considering the anatomical position described in morphology books. In situations such as the one described, where there is no internal route, the evidence to support an expert opinion is the physicochemical principles of the operation of a less-lethal weapon, a careful autopsy and a complete description of the findings.

The appearance of the entrance wounds depends on the stability and speed of the projectile when it hits the skin; because the projectile is cone-shaped, its base is heavier, its center of gravity is modified, making it unstable on its way, the rifling of the barrel stabilizes the projectile in its path so it prevents it from taking another direction, so when the cone of the projectile hits the skin it creates a rounded or oval wound depending on the firing angle. This varies if it is a modified projectile fired from a modified weapon or a crafted weapon with a non-rifling barrel [2], [4], [8] (see Figs. 6 and 7).

When a projectile impacts the skin, it elongates and tears it to allow entry of the projectile. In doing so, the rim

Fig. 6. A cone-shaped projectile (left) and a rifle barrel (right).

Fig. 7. A rubber bullet (left) and a non-rifled barrel (right).

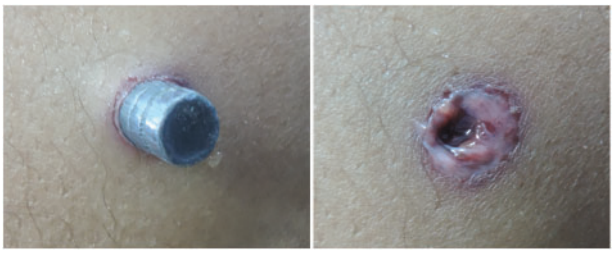

Fig. 8. Projectile impacting the skin with an oval-shaped wound (left) and a contusion ring (right).

around the bullet hole is abraded due to the friction of the skin against the inverted epidermis. The zone of erosion of the epidermis that just surrounds the edges of the wound is called the contusion ring. This zone of erosion suffers desiccation with the passage of time. The projectile, when it runs through the barrel of the firearm, collects dirt, soot and other debris until it comes out and is deposited on the skin around the edges of the entry hole, which causes a ring of dirt. All this is also influenced by the gun maintenance (see Fig. 8).

Studies carried out with polyurethane sponges that resemble skin have shown that the injuries produced by blunt trauma will generate the superficial lacerations already described in the forensic literature and that internal wounds have four types, including stellate wound; hydrated sponges resemble human skin when a rubber projectile hits the skin, the kinetic energy transmitted creates a zone of high pressure on the tissue fluids, due to the distensibility of the tissues they will absorb the impact or they will break, the truth is that even if they do not leave external injuries,

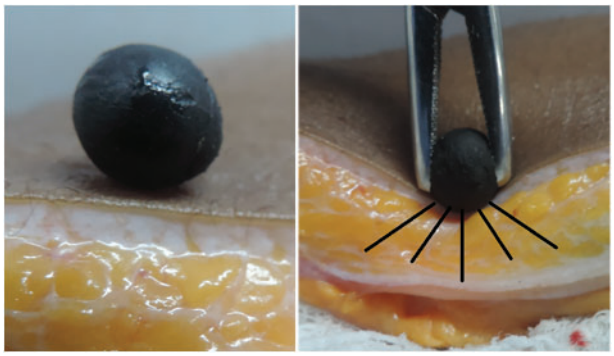

Fig. 9. Representation on the cadaver of the impact of the rubber bullet (left) and the distension of the tissues (right) impacted by the projectile.

Fig. 10. Wound from a less-lethal weapon.

there will be internal injuries such as hematomas and/or contusions [5], [6] (see Figs. 9 and 10).

The knowledge of ballistics has advanced notably through the application of bioengineering when doing simulations in cadavers, which determined the appearance of a new concept called lesion profile, initially working on pigs and then on human cadavers. This led to the generation of trauma criteria defined as the viscous criterion and the energy density required for penetration. This was achieved by doing plane-to-plane dissection in different tissue planes with different types of ammunition [13].

Previous studies tried to demonstrate the speed of the firearm projectiles in penetrating the skin, the subcutaneous tissue, and the muscle, and it was possible to verify that the skin is more resistant to penetration than the muscle. With the emergence of rubber bullets used in Northern Ireland in 1973 and in Israel in 2002 for riot control, it was observed that lethality occurs when the thorax and abdomen are hit, while in the skull, it generally bounces unless that impacts the thinnest part of the temporal bone. Likewise, the lesions leave different types of injuries on the skin, given the instability of the projectile in its displacement, as explained above, due to its rounded shape and the lack of rifling in the barrel of the fired weapon [2], [4], [8], [13], [14].

4. Conclusion

The medico-legal examination of a wound caused by a firearm projectile or a less-lethal weapon is of crucial importance in a criminal investigation because it provides many elements of judgment to the investigation, such as the shape, size of the wound, the presence or absence of gunshot residue, projectile trajectory, injured tissues and whether the injuries allow inferring the presence of intermediate targets. An appropriate firearm projectile fired from an appropriate weapon with a rifled barrel will generate variable but stable injury patterns (circular, oval, irregular or keyhole). In a modified or inappropriate weapon or with mismatched ammunition, everything will change, such as the characteristics of the wound, the direction of the projectile and the injuries.

When a projectile hits the skin, it stretches and breaks it to allow entry. In doing so, the rim around the bullet hole is worn away due to rubbing or scraping of the skin against the inverted epidermis. The zone of epidermal abrasion that immediately surrounds the edges of the wound is called the ring of contusion, which darkens when it dries. Projectiles fired from a less-lethal weapon are generally made of rubber, and the barrel of the weapon is not rifled. This substantially modifies the travel of the projectile towards the target since the fired bullet is not cylindrical at the tip and is not flattened at the base. Like a usual projectile, the lack of rifling by the weapon does not provide stability on the way to the target. For this reason, the skin lesion in most cases lacks the characteristic contusion ring (Fig. 1). For this case, the examination of the entrance wound, the internal examination, and the injuries allow us to conclude that the injury was caused by a less-lethal weapon and that the injuries described allow us to infer beyond any reasonable doubt the perpetrator-victim position by applying forensic analysis techniques for firearms with traumatic brain injury with a blunt element that does not penetrate the skull [15]–[17].

Acknowledgment

Our thanks to Milton Fernández-Taquinas, Forensic Photographer of the National Institute of Legal Medicine and Forensic Sciences of the city of Cali-Colombia, for the collaboration provided for the Development of this work.

Ethical Considerations

The specimens used for this research are protected under the strictest confidentiality.

Conflict of Interest

None of the authors and co-authors have a conflict of interest regarding the writing of the article or the deceased person.

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