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CASE REPORT Open Access

Tandem bullets: case report and ballistic analysis

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Abstract

Background: In forensic ballistics, the phenomenon of *tandem bullets* occurs when two or more bullets are ejected from the barrel of a firearm in a single shot. The injuries caused by these bullets have been described in the literature and include several possibilities, whose severity seems to be especially related to the mass increase of the exploded cartridges and to the distance at which the shots are fired, as a result of the sudden drop in kinetic energy that occurs.

Case presentation: We report the case of a subject hit by a tandem bullet, during an attempted robbery, describing the injury reported in relation to the ballistic analysis of the case and examining the dynamics in which this circumstance occurred.

Conclusions: The ballistic analysis conducted in our case confirmed that the harmful potential of "tandem bullets" is inversely correlated to the mass of the fired bullets. In our case, the exploded shot, consisting of two 38 Special caliber bullets fused together, hit the body of the subject involved with minimal kinetic energy and penetrating potential. We believe that further ballistic studies should be conducted on a cadaveric model by exploiting cadaveric donation programs for scientific research purposes, in order to investigate the wide spectrum of possible injuries that can occur, also simulating the effects of unjacketed tandem bullets.

Keywords: Tandem bullets, Ballistics, Forensic pathology, Forensic medicine, Case report

Background

Gunshot injuries have always been one of the most fascinating and studied fields in the scope of forensic ballistics (Saukko and Knight 2016).

The duty of the forensic pathologist, during the investigation, is to firstly verify the concordance between the number of entry wounds and the total amount of exit wounds in comparison with the number of projectiles recovered from the body. Oftentimes, however, the finding of a higher number of bullets compared to the number of wounds can create confusion in reconstructing the dynamics in which the shot took place.

For this reason, the phenomenon of "tandem bullets" is one of particular interest; this circumstance happens when two or more bullets are ejected from the barrel of the weapon in a single shot; another term to define the phenomenon is "piggyback bullets," and often this occurrence creates, as mentioned, quite a few doubts during the crime scene investigation because of the mismatch between the number of observed injuries, the number of found cartridges, and exploded shots (Martin and El Nasr 1939).

Various can be the mechanisms which could cause this occurrence; first of all, it is the one in which a defective cartridge is held inside the barrel as it is unexploded despite the pressure of the trigger. The bullet therefore remains inside the barrel because of the failed ignition of the cartridge, which can occur due to a low quantity of propellant or to a degradation of the cartridge which can in turn be produced either by an oil infiltration or by

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an alteration in the chemical composition of gunpowder, expecially in older cartridges (Di Maio 1999).

The use of rudimental cartridges too has been associated to an increase of *tandem bullets* cases, in relation to a higher risk of defects in cartridge ignition (Bentley et al. 1997).

Regardless of the mechanism at the base, the bullet of the defective or unexploded cartridge gets stuck in the barrel, due to the lack of the necessary power to be discharged out of the barrel; when a second shot occurs, the second bullet, arriving on the first one, held inside the barrel, causes both balls to come out from the barrel, melted together due to high pressures and temperatures that are released inside the barrel. In literature, other mechanisms underlying the phenomenon have also been described, such as the use of incorrect caliber ammunition or the presence of foreign bodies inside the barrel that can be ejected together with the bullet (du Toit-Prinsloo et al. 2013).

Injuries produced by "tandem bullets" in terms of terminal ballistics, both in murder and suicide cases described in the literature (Milano et al. 2019), include the presence of several entry holes produced by the separation of bullets during flight or a single hole of entrance into which the bullets, exploded together, penetrate (Prahlow et al. 2016).

As for internal injuries, numerous harmful scenarios have been reported: from more superficial wounds with bullet retention in subcutaneous tissues (Rabl et al. 1998) to lethal and penetrating injuries. These can involve both more exposed organs due to a lower thickness of bone and muscle tissues, such as the brain (Khau and Melinek 2019a), and deeper structures such as the heart, despite the interposition of greater osteo-muscular tissue (Fortes Picoli et al. 2020; Khau and Melinek 2019b).

Another peculiar feature is that after having hit the victim's body, the *tandem bullets*, although determining a single entry hole, can sometimes separate within the body, following separated tracks (du Toit-Prinsloo et al. 2014). In addition, there are cases in the literature in which the projectiles, ending their trajectory inside the heart cavities, end up embolizing in the peripheral vessels, creating further investigative problems for the pathologist (Fortes Picoli et al. 2020).

Case presentation

Hereby, we report the case of an attempted robbery by two armed men during which the explosion of a shot occurred, hitting the owner of the store and causing a superficial lesion at the thigh's level. During the scene investigation, three cartridges of a revolver Colt caliber 38 Special were found by the pathologist. A bullet, responsible for the death of one of the robbers, was found during the autopsy. The second and last of the bullets found was extracted in the emergency department from the thigh of the aforementioned subject.

Following the extraction, the bullet shown in Fig. 1 was found. Following a closer and microscopic inspection, it appeared to be formed by two .38 Special caliber bullets, one inside the other. The analysis of the exhibit showed the merge of the two bullets, with a significant chromatic difference between them and with the rear bullet being darker than the front one.

The findings extracted from the subject's thigh also show a partial unjacketing of the anterior bullet caused by the partial penetration of the second bullet into the ogive of the first one.

On the recordings made during the robbery, an accurate ballistic analysis was conducted on the dynamics of the shot and on the injury produced by the *tandem bullets* to reconstruct the relationship between the victim and the robber who fired.

During the scuffle between the two subjects, the robber, finding himself on the ground immobilized by the bar's owner, exploded a shot that hit the latter from the bottom up, penetrating the right thigh.

In the emergency room, the subject underwent medical evaluation followed by surgical extraction of the projectile shown in the figure and track exploration. This showed a depth limited to the cutaneous and subcutaneous layers, without the involvement of the underlying musculoskeletal tissues or deep vascular and nerve structures. The subject was therefore discharged in good condition and without significant issues.

Discussion

Historically, the evenience of "tandem bullets" is determined by insufficient propulsion of the cartridges inside the barrel with retention of the same. The subsequent explosion of a second shot determines the impact on the held ball and the expulsion of both bullets from the barrel (Spitz 2006).

Although in most cases the phenomenon involves two bullets, there are cases in the literature of three bullets shot together (Simmons 1997) and others in which the projectile is ejected in tandem with foreign bodies (Mihailovic et al. 2007).

Crucial to understanding the analysis of cases of *tandem bullets* is the discovery of the weapon from which the shots are fired. The analysis of the compatibility between the caliber of the cartridge and the weapon is important, as stated by Ersoy et al. (2012), since a smaller cartridge allows gunpowder and deflagration gases to pass into the space between the bullet and the barrel, preventing it from being ejected.

Fig. 1 The tandem bullets, merged together and extracted from the subject's thigh. Note the chromatic difference between the front bullet and the back one, which is darker than the former

Another relevant data in the ballistic analysis of the phenomenon is the firing distance, as it affects the penetration capacity of the bullet, as a result of the sudden drop in speed that occurs in such cases. In fact, assuming that the two bullets follow the linear moment principle, it is likely that an inelastic impact between the two bullets occurs inside the barrel, resulting in a speed at the exit of the barrel that can be calculated as:

$$V_t = \frac{m_p}{m_p + m_c} \cdot V_p$$

where M_p and M_c stand for the masses of the two projectiles, V_p for the speed of the tail bullet, and V_t for the total speed which, in our case, can be assimilated to the speed of impact with the subject's body (equal to 130.196 m/s) because of the minimum distance at which the shot occurred. It is therefore likely to theorize that the increase in the mass of the exploded shot, resulting from the sum of the two fused bullets, almost halves the speed with which they exit from the barrel (Rabl et al. 1998; Kneubuehl 1994). It is then possible to calculate the penetrating capacity of the *tandem bullets* inside the skin, according to the Sellier formula, based on the speed limit (V_{lim}) for its penetration, which can also be calculated as follows:

$$V_{\text{lim}} = 125\frac{G}{S} + 22$$

where G stands for the total mass of the tandem bullets, S for the section of the same, expressed in cm^2. From this, it can be deduced that the speed limit to penetrate the naked skin for the tandem bullets of our case would have been 61.75 m/s. Furthermore, the penetration of projectiles into the tissues of the body can always be defined according to the Sellier formula:

$$P = 2,3\frac{G}{S} * \ln\frac{V_t - V_{\text{lim}}}{50}$$

In our case, the analysis of the *tandem bullets* showed a total mass of 20.525 g and a section of 64.535 cm^2 from which, according to the formulas above, it is possible to obtain a penetrating capacity of the bullet of 3.19 mm, compatible with the reported injury in the emergency room.

The rarity of our case also lies in the unjacketing of the front bullet, which represents a unique occurrence, never reported in the literature. As it is known, the bullet jacket was introduced following the Hague Conferences of 1899 and 1907 in order to regulate war conflicts. In fact, the use of easily deformable bullets inside the human body was prohibited, as they were characterized by an easier tendency to fragmentation and therefore capable of causing greater damage to the internal tissues. In addition, full metal jacket bullets, compared with bare lead bullets, have a greater range, better shelf life, and resistance to deformation. These characteristics make them suitable for use in automatic weapons (such as submachine guns), while at the same time, they preserve the weapon from possible jams and leave no trace of lead deposits on the barrel rifling, which would progressively deteriorate the accuracy of the weapon itself.

For the *tandem bullets* found in our case, the partial unjacketing of the first bullet did not allow the lead core to deform or fragment, also because of the low injury potential given by the large mass of the two bullets fused together. However, we believe that in the case of smaller caliber bullets, with a resulting mass lower than one reported by us, a complete unjacketing of the anterior bullet could cause greater damage than the ones described in the literature by "tandem bullets."

Conclusions

Whenever an incongruity is found between the shells found in the scene investigation and the injuries found at the forensic inspection, the occurrence of "tandem bullets" should be suspected. The harms produced in these cases can vary so much that it could result in various scenarios, from potentially lethal blows to superficial wounds of minimal pathological significance. The ballistic analysis conducted in our case confirmed what was theorized by Sellier and others, demonstrating that the harmful potential of "tandem bullets" is inversely correlated to the mass of the fired bullets; the greater this, the less the kinetic energy of the impact to the human body. In our case, the exploded shot, consisting of two 38 Special caliber bullets fused together, due to the significant loss of speed of the "tandem bullets," caused by the greater mass, hit the body of the subject involved with minimal kinetic energy and penetrating potential. We believe that further ballistic studies should be conducted on a cadaveric model by exploiting cadaveric donation programs for scientific research purposes and augmented reality anatomy program (Argo et al. 2019), in order to investigate the wide spectrum of possible injuries that can occur, also simulating the effects of unjacketed tandem bullets (Pallocci et al. 2020).

Abbreviations

M_p: Mass of the first projectile; M_c: Mass of the second projectile; V_p: Speed of the tail bullet; V_i: Total speed; V_{lim}: Speed limit for bullet penetration; G: Total mass of the tandem bullets; S: Section of the tandem bullets, expressed in cm^2; P: Penetration in the body of the bullets, expressed in cm.

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