A Case Series of Anterograde and Retrograde Vascular Projectile Embolization

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ABSTRACT

Deaths related to firearms are common within the United States, with most cases having conspicuous projectile wounds found at autopsy. Individual gunshot wounds may be perforating or penetrating. In most cases with penetrating wounds, projectiles are relatively easily found via radiography and by following the pathway on internal examination. When a projectile is not detected in the expected region, intravascular embolization of the projectile should be suspected. Embolization may be arterial or venous, as well as anterograde or retrograde. Typically, such emboli involve small caliber bullets or shot pellets. The authors present three unusual cases of intravascular projectile embolization at autopsy, one involving shotgun slug fragment embolization, one where death was delayed, and one with retrograde embolization into the liver. *Acad Forensic Pathol.* 2018 8(2): 392-406

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INTRODUCTION

Deaths related to firearms are common within the United States with most cases having conspicuous projectile-related wounds evident at autopsy. Individual gunshot wounds may be perforating, having both entrance and exit wounds, or penetrating, having only an entrance wound, with the projectile remaining within the body. In most cases with penetrating wounds, projectiles are relatively easily found via a combination of radiography exam and by following the bullet pathway on internal examination. However, occasionally in cases involving a penetrating wound, there is failure to discover a projectile in the expected region. When this occurs, vascular bullet/projectile embolization should be suspected. The occurrence rate of vascular bullet embolization is reported to be approximately 0.3% in penetrating trauma (1). Arterial bullet embolization is most common, while approximately one-third of the cases involve venous embolization (2). Anterograde movement within the vessel, in the direction of normal blood flow, is typical; however, paradoxical bullet embolism, or embolization that occurs against the flow of blood (also known as retrograde movement or embolization), may also occur. In this small case series, the authors present details regarding three cases of bullet/projectile embolization at autopsy. The ensuing discussion focuses on the current literature and review of vascular bullet/projectile embolization.

METHODS

The cases were selected from the cases of the authors (JB, JD, and JP). Two cases demonstrate bullet/projectile emboli that travel in an anterograde fashion, whereas a single case demonstrates a bullet/projectile embolus that travels in a retrograde fashion.

CASE REPORTS

Case 1

A 10-year-old male child was found dead along with his mother and another female in a burning trailer. At autopsy, his entire body was extensively charred with

heavy soot deposition (**Image 1**). He was shot before the fire, with radiographic images demonstrating shotgun slug fragments within the posterior cranial cavity and the right side of his neck (**Image 2**). Due to his extensively fractured skull and thermal damage, a distinctive entry wound could not be discerned. However, the wound path was thought to have traversed through the scalp, skull, and brain, with a fragment of projectile subsequently embolizing to his jugular vein in an anterograde fashion, where it was recovered (**Image 3**).

Case 2

A 16-year-old male was found experiencing seizure-like activity while he was eating. He was rushed to the emergency department (ED), but was pronounced dead. Approximately one month prior to death, the teenager had reportedly sustained a gunshot wound to the back, but was alert, oriented, and had no complaints or symptoms of concern on evaluation at an ED. A chest radiograph was negative, but a bullet was present on radiograph of his abdomen/pelvis (**Image 4**). He underwent an exploratory laparotomy, which was negative, with no free blood in the abdominal cavity. It was presumed that the bullet had a markedly downward trajectory, entering the back, staying behind the peritoneal cavity, and lodging within the buttock. No further surgical exploration for the projectile was attempted, and he was discharged to home. At autopsy, a healing cutaneous entrance defect was on the left mid-to-low back. On internal examination, it was apparent that the bullet had entered the posterior subpleural aspect of the left chest wall, grazing the superior aspect of the tenth rib and the tenth thoracic vertebra, before entering the aorta (**Image 5**). There was a large (8 x 9 x 4 cm) hematoma adjacent to the defect in the aorta, a portion of which is visible in **Image 6**. This hematoma had ruptured into the left chest cavity, producing a massive hemothorax, composed of 2750 mL of liquid and clotted blood. The small caliber bullet had previously embolized downward within the aorta in an anterograde fashion and became embedded in the proximal aspect of the left internal iliac artery (**Image 7**). Postmortem blood toxicology testing was negative. The cause of death was

determined to be complications of the gunshot wound of the trunk, leading to the formation of a hematoma that subsequently ruptured. The manner of death was homicide.

Case 3

A 21-year-old man's decomposing body (**Image 8**) was found floating in the water in a drainage area along the south bank of a river. He was on probation for drug-related offences and reportedly owed money for drugs. When he was unable to pay the suspect the money he owed, he was reportedly shot with a M-16/AR-15 rifle. On external examination at autopsy, he had eight gunshot wounds with bullets entering the left side of his neck, left anterior chest, left central chest (**Image 9**), left lateral upper back, right mid-back, right lower back, right lower lateral buttock, and dorsal aspect of the right hand. On internal examina-

tion, the penetrating wound of the anterior chest wall demonstrated the following pathway: perforation of the left chest wall between anterior left ribs three and four, the anterior pericardial sac, the superior aspect of the anterior right ventricular wall, and the atrioventricular septum, with the pathway ending within the right atrium. The bullet could not be identified anywhere within the heart, lungs, inferior vena cava, or superior vena cava. A radiograph of the removed, but still intact liver, revealed the presence of a bullet (**Image 10**). Careful dissection of the hepatic vein, from its connection to the inferior vena cava, revealed that the projectile had embolized in a retrograde fashion into the hepatic venous system (**Image 11**). A partially deformed, small caliber, non-jacketed, gilded bullet was recovered from within the right lobe of the liver, where it was found wedged into a tributary of a hepatic vein (**Image 12**). The cause of death was multiple rifle wounds. The manner of death was homicide.

Image 1: Head, neck, and upper chest of extensively burned 10-year-old child in Case 1. Thermal injuries obscure the shotgun wound.

Image 2: Postmortem radiograph of extensively fractured skull in Case 1, with arrows pointing to shotgun slug fragments.

Image 3: Gross view of embolized fragment of shotgun slug (arrow) within the jugular vein in Case 1. Note that the projectile is visible through the intact, translucent venous wall.

Image 4: Postmortem radiograph of pelvis from Case 2, with bullet.

DISCUSSION

A bullet/projectile from a modern firearm typically follows a relatively straight course within a body, either exiting the body (a perforating wound) or being recovered from within the body at the end of the bullet pathway/track (a penetrating wound). However, in some cases, vascular embolization of a bullet/projectile or fragment occurs, such that there is failure to discover the bullet in the expected region, radiologically or during autopsy dissection.

Intravascular embolization can occur within the arterial or venous systems. The most common sites of entrance for a bullet into the arterial system are the aorta

and the heart, whereas entrance into the venous system typically occurs via the vena cava and iliac veins (3). Although embolization usually occurs immediately following entrance of the bullet into the circulation, delays as long as 26 days have been reported (4). According to DiMaio, bullet emboli are usually associated with small-caliber, lightweight, low-velocity missiles that possess low kinetic energy—and if these missiles lose their forward velocity on penetration of a major blood vessel or the heart, they are able to enter the circulation and embolize to a distant site (3). In addition to small caliber projectiles, birdshot pellets and small fragments of projectiles are also capable of embolization. A projectile or fragment that has a specific gravity greater than blood is capable of traveling

Image 5: Bullet perforation site of the aorta in Case 2, as discovered at autopsy.

against the flow of blood in a retrograde fashion, also known as “paradoxical bullet embolism”(5). Thus, depending on the trajectory and the properties of the projectile itself, it may travel in an anterograde or retrograde fashion through the arterial or venous system.

The definition of “embolism” is the lodging of an “embolus,” a blockage-causing piece of material, inside a blood vessel (6). Although uncommon, migratory intraluminal bullets may produce complex nonvascular “embolization” scenarios in patients with gunshot wounds. A rare case of gastrointestinal bullet “embolism” was described where a small-caliber bullet perforated the small bowel, migrated distally, and eventu-

ally was discovered in the distal colon, which resulted in a missed injury, leading to sepsis and the demise of the patient (7). Smalls and Siram have reported a unique case of a “wandering” bullet in which the bullet caused esophageal injury and was found lodged in the stomach (8). DiMaio has depicted two interesting cases of bullets expelled through the oral orifice—in the first case, a bullet from an entry point in the back was recovered from the oral cavity, whereas in the second case, a bullet from a chest wound that halted within the lungs was eventually coughed-up into the mouth (3). Another rare case involved the spontaneous migration of a bullet within the spinal subarachnoid space, which caused delayed radicular symptoms (9).

Image 6: The site of hematoma rupture into the left chest cavity as seen at autopsy from Case 2. Note that most of the large hematoma is hidden from view in this photograph, as it is behind the aorta.

Image 7: Gross view of small caliber bullet recovered from within the proximal left internal iliac artery in Case 2.

The vascular embolization phenomenon is not limited to detection at autopsy, as intravascular bullet embolization also occurs in living survivors of gunshot injuries. The clinical medical literature has numerous reports of intravascular bullet emboli, including cases of arterial embolization (2, 10-13), venous embolization (2, 10, 14, 15), and retrograde embolization (16). Several unique cases have been reported, including shotgun pellet embolization to a coronary artery and a projectile paradoxical embolization via a patent foramen ovale from the left external iliac vein to the left common iliac artery (17, 18). In a 1990 review of the English language literature, Michelassi et al. describe 153 cases of bullet emboli, of which 100 were arterial and 53 were venous (2). In their review, most bullet emboli followed the normal direction of blood flow; however, 15% of venous bullets embolized in a retro-

grade manner (2). One in ten arterial emboli occurred following a right-heart or venous injury and 80% of arterial emboli were symptomatic, while only one third of venous emboli were symptomatic (2).

A variety of potential explanations may account for a discrepancy when attempting to account for the number of entry and exit wounds, the number of projectiles accounted for at the scene of the shooting, and the number of projectiles evident on radiographic examination. A recent review provides a relatively complete list of the various situations and possible explanations for when such a discrepancy exists (19). If there is any discrepancy between the number of entry and exit wounds, or if the clinical signs and radiographic imaging do not correlate with the injuries, suspected bullet embolism should be one of

Image 8: The decomposed body of the man from Case 3, after being removed from the water.

several possible explanations. The missing projectile should be thoroughly accounted for by a meticulous search. As such, a high degree of suspicion and diligent evaluation of patients with gunshot wounds is of critical importance in order to identify situations where projectile embolism may have occurred. Case 2 exemplifies this fact within a person who initially survived his injuries. Had the clinicians and surgeon in this case recognized the fact that the bullet seen in the pelvis region on radiograph actually represented an intra-arterial embolic phenomenon, they would have realized that a vascular (aortic) injury had occurred. Knowing this, they would have likely explored the chest in order to identify and repair the aortic injury, thus possibly preventing the delayed death related to the gunshot wound.

CONCLUSION

The cases presented serve as examples of somewhat unique variations of bullet/projectile intravascular embolization. Such cases can involve arteries or veins, and be anterograde or retrograde. Intravascular projectile embolism can cause difficulty at forensic autopsy, while pathologists attempt to account for projectile pathway and location. The first case, involving an anterograde venous embolism, highlights the fact that shotgun slug fragments may embolize. The location of the projectile fragment within the jugular vein might be explained by a combination of gravity (child was presumably standing or sitting upright when shot) and possibly the “vacuum action” created within the severed vein as the heart continued to

Image 9: Entrance wound on the left central chest from Case 3.

Image 10: Radiograph of liver from Case 3, showing the presence of a small caliber bullet.

pump for a short time. The second case, which involved an anterograde arterial embolism, represents a unique case where embolization was not recognized until several weeks following the shooting. The third case involved a retrograde venous embolism into a branch of the hepatic vein within the liver. The exact explanation for the retrograde venous embolism could not be ascertained with certainty; however, possible factors might include passive gravitational forces and increased “back-pressure” on the inferior vena cava,

via the pumping action of the heart, with forces transmitted via the bullet track through the atrioventricular septum. In addition to presenting challenges for forensic pathologists at autopsy, projectile emboli can pose problems for clinicians and surgeons. Case 2 in this series highlights the importance of identifying bullet emboli in patients who initially survive a gunshot wound. Failure to recognize projectile embolism in the clinical setting can have lethal consequences.

Image 11: Careful dissection of the hepatic vein in Case 3, from its connection to the inferior vena cava, revealed that the projectile (arrow) had embolized in a retrograde fashion into the hepatic venous system.

Image 12: Close-up view of the small caliber bullet found wedged into a tributary of a hepatic vein, after opening the vein at autopsy in Case 3.

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