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Case Study

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Bullet Vascular Injury at a Pediatric Age: A Two-Case Report from Saudi Arabia

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ABSTRACT

Gunshot injuries are a rare cause of vascular injury in the pediatric age group, mostly occurring accidentally. They are very serious injuries and could even be life- or limb-threatening, even with slow- velocity bullets. Here, we report two cases of vascular injury induced by different types of weapons. The first case was a four-year-old boy who presented with a left axillary artery injury caused by a gunshot bullet. The diagnosis was made by a computerized tomography angiogram (CTA). CTA showed a pseudo-aneurysm and complete disruption of the left axillary artery at the upper limb. The injury was treated immediately with exploration of the axillary artery, debridement of the injured area of the artery, and repair with an interposition saphenous graft. Postoperatively, the patient did well with good healing of the wound and regained normal upper limb pulses. The second case was a 10-year-old boy who was shot with an air rifle from a very short distance. This caused the bullet to directly penetrate the left side of his neck and injure the anterior surface of the left common carotid artery (CCA). Initially, the CTA missed the diagnosis, but the injury was diagnosed by duplex ultrasound on the third day of admission, which showed a pseudo-aneurysm at the anterior surface of the left CCA. The patient did not manifest any neurological signs or symptoms. He underwent surgical exploration of the CCA, and primary repair of the small hole located at the anterior wall. The patient recovered well with no neurological events.

Key words: *Bullet, Pediatric, Vascular injury, Air-gun, Gunshot, Firearm*

INTRODUCTION

Penetrating vascular injuries caused by bullets are very serious injuries and could even be life- or limb-threatening, even with slow velocity bullets.

The penetrating injuries caused by firearm pullet injury in pediatric age group is the leading cause of death in U.S. children. In a recently published study, a total of 45288 child were involved in penetrating firearm injury and only 12% of them have passed away. The children who died were young, severely injured, in shock and had poly trauma at the time of presentation [1]. The firearm penetrating trauma are associated with great severity and health care utilization if compared with other penetrating trauma from other mechanisms [2]. Another similar study in Scandinavian country, found that firearm and penetrating injuries were increasing over the years. The study included young patient with median age of 12.9 years and showed a significant increase in vascular injuries with mortality rate of 12.8% [3].

To date, there have been no reports about the incidence of this specific type of vascular injury at the pediatric age in Saudi Arabia. A recently published report about penetrating injuries in the pediatric age group which included a percentage of gunshot injuries, though not specifically vascular injuries found that 10% of the trauma in the pediatric age group are penetrating injuries, and out of this 10%, about 12.3% are due to gunshots [4]. A firearm gun's bullet can cause a very serious and potentially deadly injury in the pediatric age group compared to an air-gun bullet [5]. However, even though an air-gun is considered a less-lethal weapon but could still cause significant injury if it occurs at a very short distance [6].

Case presentation

The first case was a four-year-old child who was referred by a pediatric surgeon as there were no pulses felt in the left upper limb. The patient initially presented to the emergency room with pain in the left upper limb with a penetrating wound at the left shoulder for one hour before the presentation. His brother explained that he noticed the blood on the left shoulder of his little brother as soon as he walked out of the car in their home's garage, and at the same time noticed a small bullet hole in the ceiling of the garage which was made from aluminum. At that time, there was news of gunshots in the neighborhood where the child lived. The child was medically free, he was conscious but in pain and holding his left arm with his right arm. His blood pressure was 135/77 and his pulse was 102 beats/min. The gunshot inlet was at the tip of the shoulder with no outlet, and there was a hematoma at the lateral left chest wall up to the level of the sixth rib. Pulses were absent at the left brachial, radial, and ulnar arteries. The hand was viable with a mild decrease in the capillary filling. It was difficult to assess the movement and neurological examination as it was very painful to the patient. The other limb was normal, and all investigations were within the normal range. The chest X-ray showed the bullet outside the chest cage **(Figure 1)**. A CT-Angiogram was requested which showed pseudo-aneurysm at the left axillary artery with complete disruption of the flow with weak reconstruction distally by the collateral blood flow **(Figure 2)**.

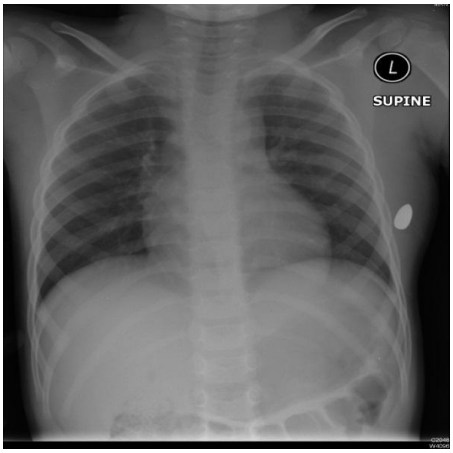


Figure 1. Chest X-ray, the site of the bullet is outside the chest cage at the left chest wall

a) b)

Figure 2. CTA with 3D construction; Small pseudo-aneurysm at the left axillary artery with complete disruption. with flow reconstruction distally to the brachial artery by collaterals, showing lighter contrast at the distal vessels compared to the proximal axillary artery.

The patient was taken to the operating theater where the axilla was explored and the axillary artery was dissected and controlled proximally and distally. We found that injury was at the axillary artery without any

injury to the nerves or any other surrounding structures **(Figure 3)**. The area of injury at the artery was debrided until the viable part of the artery was exposed. The two ends of the artery could not be approximated without significant tension; therefore, a saphenous vein was harvested from the patient's proximal left thigh for about 2-3 cm and reversed. After that, an end-to-end anastomosis between the artery and the two ends of the vein graft was performed and about 1 cm of the vein was used. Good flow was established through the axillary artery, and the radial and ulnar pulses were regained. The bullet was removed at the same setting from an incision at the lateral aspect of the chest wall **(Figure 4)**. The patient recovered very well without any complications.

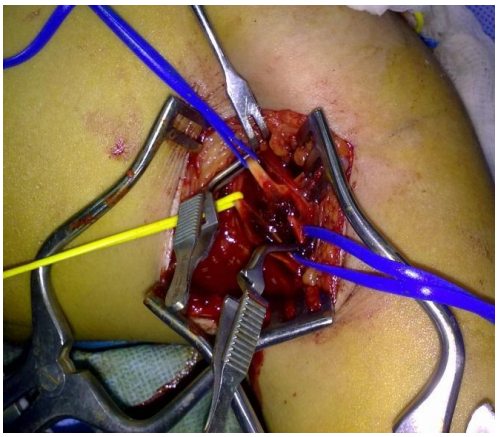


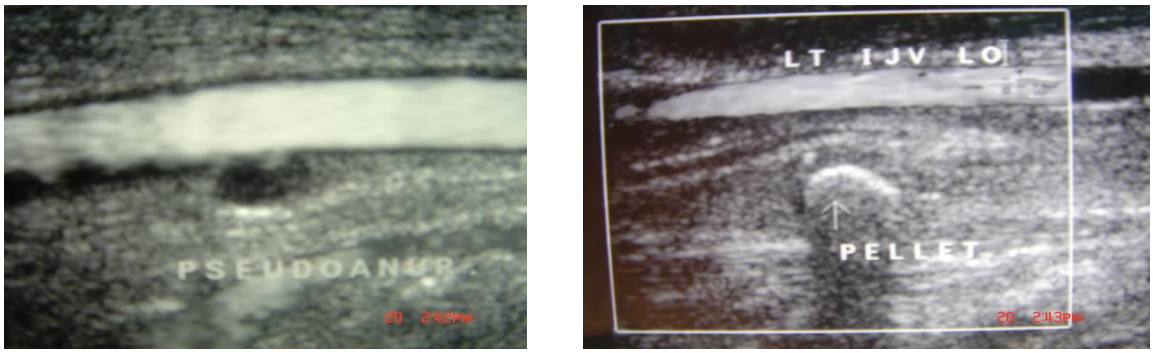
Figure 3. The area of the axillary artery injury where proximal and distal ends of the artery were controlled

Figure 4. The bullet after it was removed from the chest wall

In the second case, the patient was ten years old, referred to vascular surgery 3 days after being admitted to the pediatric intensive care unit (PICU) for observation. He was injured by an air rifle shot to the left side of his neck from a close distance. He was in the back seat of the car, sitting in the middle. The air rifle was lying between the two front seats. When the front passenger was seated, the air rifle went off, resulting in direct injury to the left side of his neck. He was admitted to the PICU complaining of neck pain with no other signs or symptoms. On admission, a CTA was performed and no significant abnormalities were found. The CTA was reviewed by a vascular surgeon three days after admission and before discharge. The patient was still complaining of pain in the neck at the site of the injury with mild tenderness **(Figure 5)**. Therefore, a duplex ultrasound was requested.

Figure 5. The entrance of the bullet at the left anterior surface of the neck at zone 2

The duplex ultrasound revealed a pseudo-aneurysm at the anterior wall of the left CCA, confirming the site of the bullet **(Figure 6)**.



a) b)

Figure 6. Duplex ultrasound, a small area of the pseudo-aneurysm at the wall of the left CCA and the site of the air-gun bullet deep into the muscle just posterior to the left IJV

Based on those findings, the patient was taken to the operating theater where the left CCA was explored and controlled with a vascular sling proximally and distally. After that, the area of the injured artery was cleaned. After debridement, a small hole was seen **(Figure 7)**. It was repaired by a figure of eight direct suturing. The bullet was removed through the same incisional wound and was found impeded posteriorly into the neck muscle just behind the internal jugular vein (IJV). The patient recovered very well and was discharged home in a good condition without any complications.

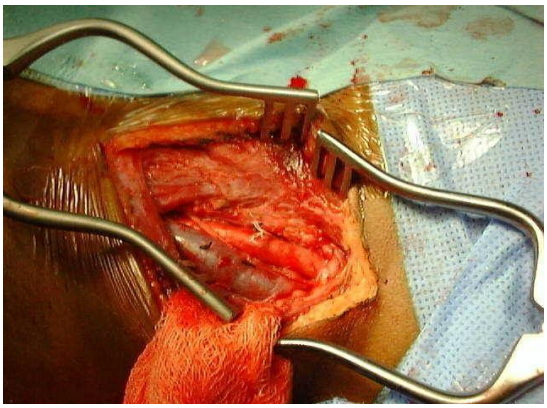


Figure 7. The left IJV and CCA with the area of the injury after suturing and repair

RESULTS AND DISCUSSION

Trauma is one of the most common causes of morbidity and mortality in the pediatric age group that can be avoided [7]. Trauma induced by firearms and air-guns in the pediatric age group can cause serious injury and often requires intervention. The proportion of self-inflected pediatric firearm injury and mortality are increasing [1]. Most firearm injuries in the pediatric age group are non-intentional or indirect injuries [5]. Such as in our first case, where the bullet reached the child from a firearm indirectly. Despite that, it still caused significant and serious injury to the axillary artery. There is a significant difference in the inpatient mortality rate from firearm injuries when compared to air-guns. However, it is crucial to note that, despite their status as a "toy," air-guns have been linked to serious injuries and hospitalizations [5]. Gunshot wounds from handgun and rifle ammunition vary in severity depending on where the in body and the consequences of the penetrating projectiles' ballistic qualities. Ballistic parameters like the impact velocity and energy ought not to be separately evaluated, as their specific consequences are dictated by the interaction between the tissues and incoming magazines. The severity of the penetrating injury of the gunshot bullet depends on the nature of the wound impacted by the projectile’s dynamic and the penetrated tissue’s restricted response [8].

In the United States, weapons have a mortality rate of 10.26 per 100,000 people, with 606 (1.9%) of these deaths being accidental [9]. Gunshots caused the most serious injuries in children aged 18 and under, with 32%

requiring major surgery, 8% resulting in in-hospital mortality, and an average cost of USD 28,510 per patient [10].

In Scandinavians countries there was a significant increase in firearm injury over one year study with mortality rate of 12.8%. The median age affected was 12.9 year old and 93% of them were males. There was a significant increase in vascular injuries (17%) during the study period [3].

Neighborhoods associated with firearm injuries were characterized by lower median householder income and higher level of poverty compared to median state level [11]. When a projectile collides with an object, the projectile's energy is transferred to the target. The following equation can be used to calculate the kinetic energy of this projectile [9]:

$$\text{Kinetic energy} = (\text{mass} \times \text{velocity} \times \text{velocity})/2 \quad (1)$$

An object travelling at a speed of more than 609 m/s is classified as a high-energy missile. Shock waves, transitory and permanent cavitations all cause harm to the targets of these high-energy projectiles. At velocities less than 457 m/s, low-energy missile injuries occur. These injuries, like those caused by air rifles and weapons, are caused by a distinct mechanism. Rather of the consequences of brief cavitations, direct effects on tissues, like crushing within the missile tract and lacerations, occur. The muzzle velocity isn't the only criterion that determines how much harm an air rifle pellet can cause. The pellet's velocity can rapidly degrade over time, making the pellet's velocity at the target more important in terms of tissue damage. For contrasting the power of different air weapons, muzzle velocity is a helpful gauge [6].

The origins of modern air-guns can be traced back to the 15th century. They were known as wind chambers, and they were built with a mechanism that connected an air reservoir to a cannon barrel. Modern air-gun pellets have the potential to cause significant, if not fatal, injuries. Every year, one person in the United Kingdom dies as a result of an air-gun injury [12]. Air-guns can achieve muzzle velocity of up to 106.68 meters per second. Moreover, 'dieseling,' a procedure in which petroleum oil is poured in the barrel and lit by the passing pellet's generated heat, causing in an explosion that increases the velocity of the pellet, leading to higher power of penetration, can make such weapons even more hazardous. To make air guns and pellets safer and more difficult to change, certain standards surrounding their design have been introduced [6].

In the literature, there is an alarming trend of increasing the occurrence and brutality of air-gun pellet injuries. The majority of pellet injuries from air guns occur in kids and adolescents (6-12 years) [4, 13], with the head and neck being the most commonly affected areas. The neck's airway and neurovascular compositions make it a potentially life-threatening location of injury, yet the severity of an air-gun injury isn't often clear at first. The findings of this research indicate, the second patient who was injured with an air rifle pellet presented with neck pain and mild tenderness only. There have been accounts of penetrating injuries to the central nervous system in which the patient and parents were unaware that the pellet had even entered the epidermis [14, 15]. Additionally, the diagnosis of vascular injuries by air-guns can be challenging and dangerous because the pellet may not be palpable or even show any signs of penetration, which could easily lead to it being treated as a minor injury or missed altogether [16, 17]. This can lead to catastrophic results. In our second case, the air-gun pellet penetrated the left CCA with no signs of hematoma formation or finding in the CTA. Only when the duplex ultrasound was performed was it discovered that the pellet impeded deeply in the neck muscles behind the IJV.

CONCLUSION

The type and location of the wound, rather than the weapon that caused it, determines the therapy required. Bullet injuries can be lethal, and they should not be taken lightly by doctors or emergency services. In the treatment of such injuries, a comprehensive analysis and history, as well as the use of proper imaging techniques, are essential. Ultrasound and CT-Angiogram are two non-invasive and invasive radiological procedures that can help locate projectile injuries in children. As the incidence and severity of such injuries are increasing in the pediatric age group, stricter legislation and public education are needed to reduce firearm weapon availability and to make air-guns safer and clarifying that they are not to be used by untrained people.

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