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Pediatric Bullet-Related Vascular Injuries: A Case Report of Two Incidents in Saudi Arabia

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ABSTRACT

Pediatric vascular injuries caused by gunshot wounds are rare, often occurring due to accidents, and can be potentially life-threatening, even when caused by low-velocity projectiles. We present two cases of vascular trauma resulting from different types of weapons. The first case involved a 4-year-old boy who sustained an injury to the left axillary artery from a gunshot. A computed tomography angiogram (CTA) confirmed a pseudo-aneurysm and complete disruption of the artery. The child underwent immediate surgery, which included exploration, debridement, and repair of the artery with a saphenous graft. The child recovered without complications, with good wound healing and restored pulses in the affected limb. The second case was a 10-year-old boy who was shot in the neck with an air rifle at close range. The bullet penetrated the left side of his neck and injured the anterior portion of the left common carotid artery (CCA). Although the initial CTA failed to detect the injury, duplex ultrasound on the third day confirmed a pseudo-aneurysm in the CCA. The child showed no neurological symptoms and had a successful surgical repair of the injury, recovering fully without neurological complications.

Keywords: Pediatric, Bullet injury, Vascular trauma, Air rifle, Gunshot wound, Firearm injury

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Introduction

Penetrating vascular injuries from gunshots are critical and can be life-threatening, even when caused by low-velocity bullets. Among children in the United States, firearm-related injuries are the leading cause of death, with a recent study involving 45,288 children showing that only 12% of them succumbed to their injuries. The children who died were typically younger, very injured, in shock, and presented with multiple traumas [1-3]. Firearm-related injuries are notably more severe and require greater healthcare resources than other forms of penetrating trauma. A similar study from Scandinavia highlighted an increasing trend in firearm-related and penetrating injuries, especially among young patients, with a median age of 12.9 years, and a mortality rate of 12.8% [2-6]. In Saudi Arabia, there have been no reports on the incidence of pediatric vascular injuries caused by gunshots. A recent study on pediatric trauma, which included some gunshot injuries, found that 10% of pediatric trauma cases involved penetrating injuries, with 12.3% of these being caused by gunshots. Although air guns are typically considered less lethal, they can still cause significant harm when the shot occurs at close range.
We present two cases of vascular trauma resulting from different weapon types.

Case presentation

The first case involves a four-year-old boy who was referred by a pediatric surgeon after being found without detectable pulses in his left upper limb. He had initially arrived at the emergency room with left shoulder pain due to a penetrating wound sustained an hour before presenting. His brother noticed blood on the child's left shoulder and a small bullet hole in the garage ceiling, alongside reports of gunshots in the neighborhood. The child was alert but in pain, clutching his left arm with his right. His blood pressure was 135/77 mmHg, and his pulse was 102 beats per minute. A gunshot wound was observed at the tip of the left shoulder, with no exit wound and a hematoma extending to the lateral left chest wall up to the sixth rib. There were no pulses in the left brachial, radial, or ulnar arteries, although the hand appeared viable with slight capillary refill delay. Due to the pain, it was challenging to assess movement or conduct a full neurological exam. The right limb appeared normal, and all lab results were within normal limits. Chest X-rays showed the bullet outside the chest wall. A CT angiogram revealed a pseudo-aneurysm and complete disruption of the left axillary artery, with some collateral blood flow allowing weak distal reconstruction **(Figures 1 and 2)**.

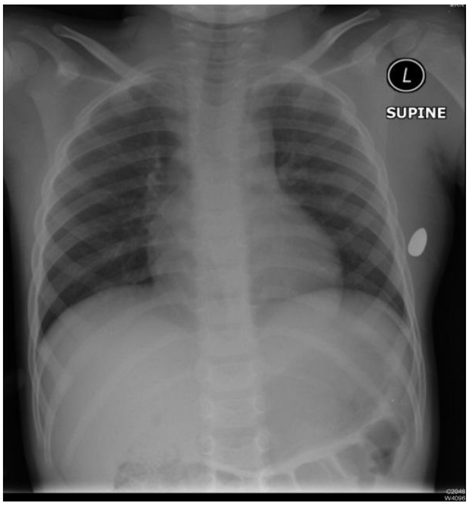


Figure 1. Chest X-ray, the site of the bullet is outside the chest cage at the left chest wall

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 promptly taken to the operating room, where the surgical team explored the axillary region. The axillary artery was identified and carefully isolated, with proximal and distal control of blood flow achieved. The injury was confined to the artery itself, with no damage observed to surrounding nerves or tissues **(Figure 3)**. The damaged section of the artery was cleaned until healthy tissue was visible. Due to the inability to directly approximate the artery ends without significant tension, a 2-3 cm segment of saphenous vein was harvested from the patient's left thigh, reversed, and used to create a graft. An end-to-end anastomosis was performed, with about 1 cm of vein being used to connect the artery. After the procedure, blood flow through the axillary artery was restored, and normal pulses were reestablished in the radial and ulnar arteries. In addition, the bullet was removed through an incision made on the lateral chest wall **(Figure 4)**. The patient recovered well, with no complications during the postoperative period.

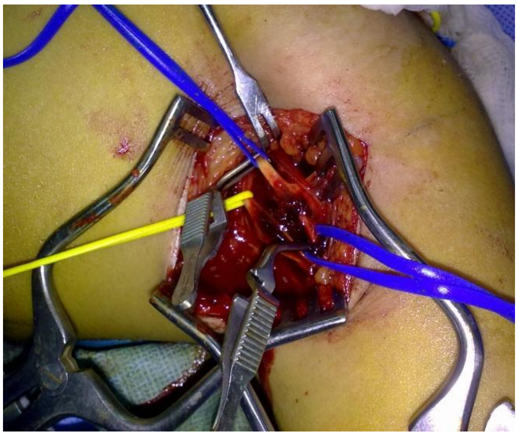
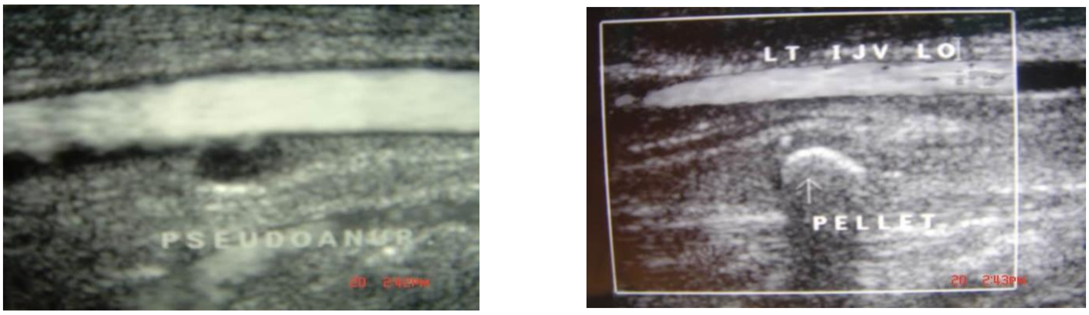


Figure 3. The area of the axillary artery injury where the proximal and distal ends of the artery were controlled

Figure 4. The bullet was removed from the chest wall

In the second case, a 10-year-old boy was referred to vascular surgery three days after his admission to the pediatric intensive care unit (PICU), where he was monitored for observation. He had been injured by a close-range shot from an air rifle that struck the left side of his neck. The accident occurred while the boy was seated in the middle of the backseat of a car, with the air rifle lying between the front seats. When the passenger in the front seat got in, the rifle discharged and hit the boy in the neck. At the time of admission, the boy reported neck pain, but he showed no other concerning symptoms. A computed tomography angiogram (CTA) was performed, which initially showed no significant issues. However, after three days of monitoring and ongoing pain in his neck, the vascular surgeon reassessed the patient and ordered a duplex ultrasound to further examine the injury **(Figures 5 and 6)**.

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



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

Following the diagnostic results, the patient was brought to the operating room, where the left common carotid artery (CCA) was accessed and controlled with vascular slings both proximally and distally. Afterward, the injured area of the artery was thoroughly cleaned. Upon debridement, a small perforation in the artery was observed. This was repaired using a figure-of-eight suturing technique. The bullet, which was lodged behind the internal jugular vein and embedded in the neck muscle, was removed through the same incision. The patient made a full recovery and was discharged in stable condition, without any complications **(Figure 7)**.

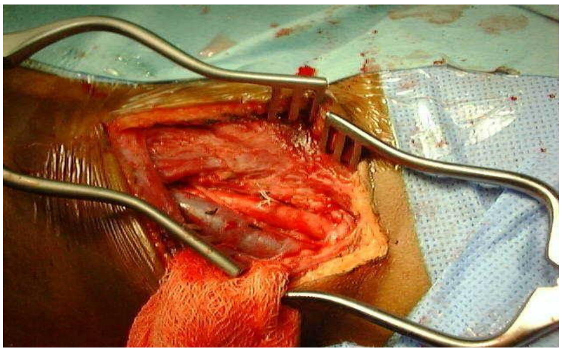


Figure 7. The left IJV and CCA with the area of the injury after suturing and repair

Results and Discussion

Trauma is one of the leading causes of both morbidity and mortality among children, yet many of these incidents are preventable [7]. Firearm and airgun-related injuries in children can result in severe harm and often necessitate immediate medical intervention. The rates of self-inflicted firearm injuries and fatalities in children are rising [1]. Most firearm-related injuries in this age group are accidental or indirect, as seen in the first case, where the child was injured by a bullet fired indirectly from a firearm. Although air guns are often perceived as toys, they can also cause significant injuries and hospitalizations [5]. While the severity of injuries from gunshots varies depending on the caliber of the weapon, the location of the wound, and the characteristics of the projectiles, it is important to understand the dynamics involved in how the projectile interacts with body tissues. The extent of the injury is influenced by factors such as the bullet’s speed and energy, as well as the response of the tissues penetrated by the bullet [8].

In the United States, firearms are responsible for a mortality rate of 10.26 deaths per 100,000 people, with 1.9% of these fatalities being accidental [9]. Firearm injuries, particularly gunshot wounds, cause the most severe trauma in children under the age of 18, with 32% of these cases requiring major surgery. These injuries are associated with an 8% in-hospital mortality rate and an average treatment cost of approximately USD 28,510 per patient [10].

In Scandinavian countries, a one-year study revealed a significant rise in firearm injuries, with a mortality rate of 12.8%. The median age of those affected was 12.9 years, and 93% of the cases involved males. Vascular injuries increased significantly during the study period, with 17% of the cases involving such injuries [3].

Neighborhoods where firearm injuries are more common tend to have lower median household incomes and higher poverty rates when compared to the state average [11]. The transfer of energy when a projectile hits an object can be described using the following equation for calculating the projectile's kinetic energy [9]:

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

Projectiles traveling at speeds over 609 m/s are classified as high-energy missiles. These high-speed projectiles generate significant harm through shockwaves and cavitation effects, both temporary and permanent. Conversely, low-energy projectiles, such as those from air rifles, typically travel below 457 m/s. The injuries caused by these lower-speed projectiles differ, as the damage results more from direct tissue impact, such as crushing or tearing, rather than the brief cavitations caused by faster-moving objects. The speed of the pellet when it hits the target is a more crucial factor in determining the damage, as its velocity decreases over distance. The muzzle velocity serves as a useful standard when comparing different types of air guns, although it does not fully determine the potential damage caused [6].

Air guns, with roots dating back to the 15th century, originally known as "wind chambers," are capable of causing serious injuries today. A person dies annually in the UK due to an air-gun injury [12]. Air guns can achieve muzzle velocities of up to 106.68 meters per second, and certain modifications, like "dieseling," can increase their power. Dieseling occurs when petroleum oil, added to the barrel, ignites from the heat generated by the passing pellet, creating an explosion that boosts the pellet's velocity and penetration. Stricter regulations now govern air guns and pellets to ensure they are safer and harder to alter [6].

The incidence and severity of injuries from air-gun pellets are alarming, especially in children and adolescents between 6 and 12 years old [4, 13]. The head and neck are the most commonly affected regions. The neck's complex structure, which includes vital airway and neurovascular components, makes it particularly vulnerable. However, air-gun injuries may not immediately present as severe, as demonstrated in the second case of our study, where a 10-year-old patient complained only of neck pain and tenderness. In some instances, the pellet's impact may go unnoticed, and it may even penetrate without the patient or family realizing it [14, 15]. Diagnosing vascular injuries caused by air guns can be difficult, as the pellet may be undetectable or leave no visible signs, potentially leading to misdiagnosis or delayed treatment [16, 17]. In our second case, the pellet penetrated the left common carotid artery (CCA), yet no initial signs were detected on the CT angiogram. It was only through a duplex ultrasound that the pellet's location behind the internal jugular vein (IJV) was identified.

Conclusion

The management of firearm and airgun injuries should focus on the nature and location of the wound rather than the weapon involved. Bullet-related injuries can be fatal and must not be underestimated by healthcare providers. Comprehensive patient evaluation, including a detailed history and appropriate imaging techniques, is critical. Methods such as ultrasound and CT angiograms are essential tools in diagnosing projectile-related injuries in children. With the rising frequency and severity of such injuries, especially in the pediatric population, there is an urgent need for stronger regulations and public education to reduce access to firearms and enhance the safety of air guns. Additionally, clear guidelines should be established regarding the use of air guns, emphasizing that they should not be used by individuals without proper training.

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Ethics Statement: None

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