Successful treatment and survival after gunshot wound to the aortic arch with bullet embolism to superficial femoral artery

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ABSTRACT

Mortality after gunshot wounds to the thoracic aorta ranges from 92% to 100%. Survival is almost always in patients with injury from low-caliber, low-velocity bullets with hemorrhage contained by the wall of the aorta. Bullet embolization, even rarer with a reported incidence of 0.3% of vascular injuries, is most commonly found during autopsy. We report the successful treatment and survival of a patient who presented with a large-caliber gunshot wound to the aortic arch with contained rupture and bullet embolization from the aortic arch to the superficial femoral artery. The patient remained functionally independent and was discharged without complication. (J Vasc Surg Cases and Innovative Techniques 2019;5:283-8.)

Keywords: TEVAR; Bullet; Embolization; Aortic arch; Gunshot wound

Vascular bullet embolization is an unusual and unexpected finding after firearm injuries. Bullet embolism should be suspected when there are an odd number of bullet wounds and the location of embolism is suggested by the presence of ischemia. Penetrating gunshot injuries to the thoracic aorta with subsequent bullet embolism to a peripheral artery are exceedingly rare. Bullet embolism is often found during autopsy evaluation because of the extremely high mortality associated with such thoracic injuries.[1,2] In those unusual cases reported in the literature in which the patient survived, historically the vascular injuries were repaired by open surgery followed by embolectomy to extract the bullet.[3-5] Advances in endovascular surgery in the past two decades have changed the standard of care for blunt traumatic injuries of the thoracic aorta and aortic arch, with both trauma and vascular surgery literature recommending endovascular stenting as a first-line approach because of improved outcomes.[6,7] Endovascular repair of penetrating aortic injuries is also possible, but associated injuries as well as lack of emergently available endovascular capabilities frequently mandate open exploration with poor survival.[1] We present a case of gunshot injury to the aortic arch with bullet embolization to the left superficial femoral artery (SFA) that was successfully treated with thoracic endovascular aortic repair (TEVAR) and removal of the bullet. The patient provided consent for this case report, and it was exempt from Institutional Review Board approval at our institution.

CASE REPORT

A 34-year-old man sustained a gunshot to the chest just above the suprasternal notch from an assailant who shot him through a door with a high-caliber handgun. He was taken to a local emergency department, where he had stable vital signs and underwent computed tomography angiography (CTA) of his chest, which demonstrated an injury to the aortic arch proximal to the left subclavian artery origin with associated mediastinal hematoma and left hemothorax. He was urgently transferred to our facility for higher level of care.

On presentation to our institution, the patient was hemodynamically stable with a heart rate of 87 beats/min and blood pressure of 114/64 mm Hg, with a wound just above the sternal notch and no other wounds to suggest an exit site. The only other abnormal finding was a lack of palpable pulses in his left lower extremity, which was warm with Doppler signals and asymptomatic. A chest radiograph demonstrated a left hemothorax and no retained bullet (Fig 1, *A*). To evaluate his access vessels, CTA of his chest, abdomen, and pelvis was repeated (Fig 1, *B* and *C*), which confirmed the injury to the aortic arch with pseudoaneurysm, mediastinal hematoma, and left hemothorax and demonstrated a hyperdense object in the left proximal SFA.

The patient was urgently taken to a hybrid operating room for TEVAR. Coverage of the left subclavian artery was planned, given the location of the injury. Bilateral vertebral arteries were patent and equal in size. TEVAR was performed with two conformable TAG endografts (CTAG; W. L. Gore & Associates, Flagstaff, Ariz) because of size mismatch in aortic diameter at the proximal (24 mm) and distal (20 mm) landing zones. A 26- ×21- ×100-mm CTAG was deployed distal to the left subclavian artery, and a 28- ×28- ×100-mm CTAG was then deployed distal to the left common carotid artery without shuttering.

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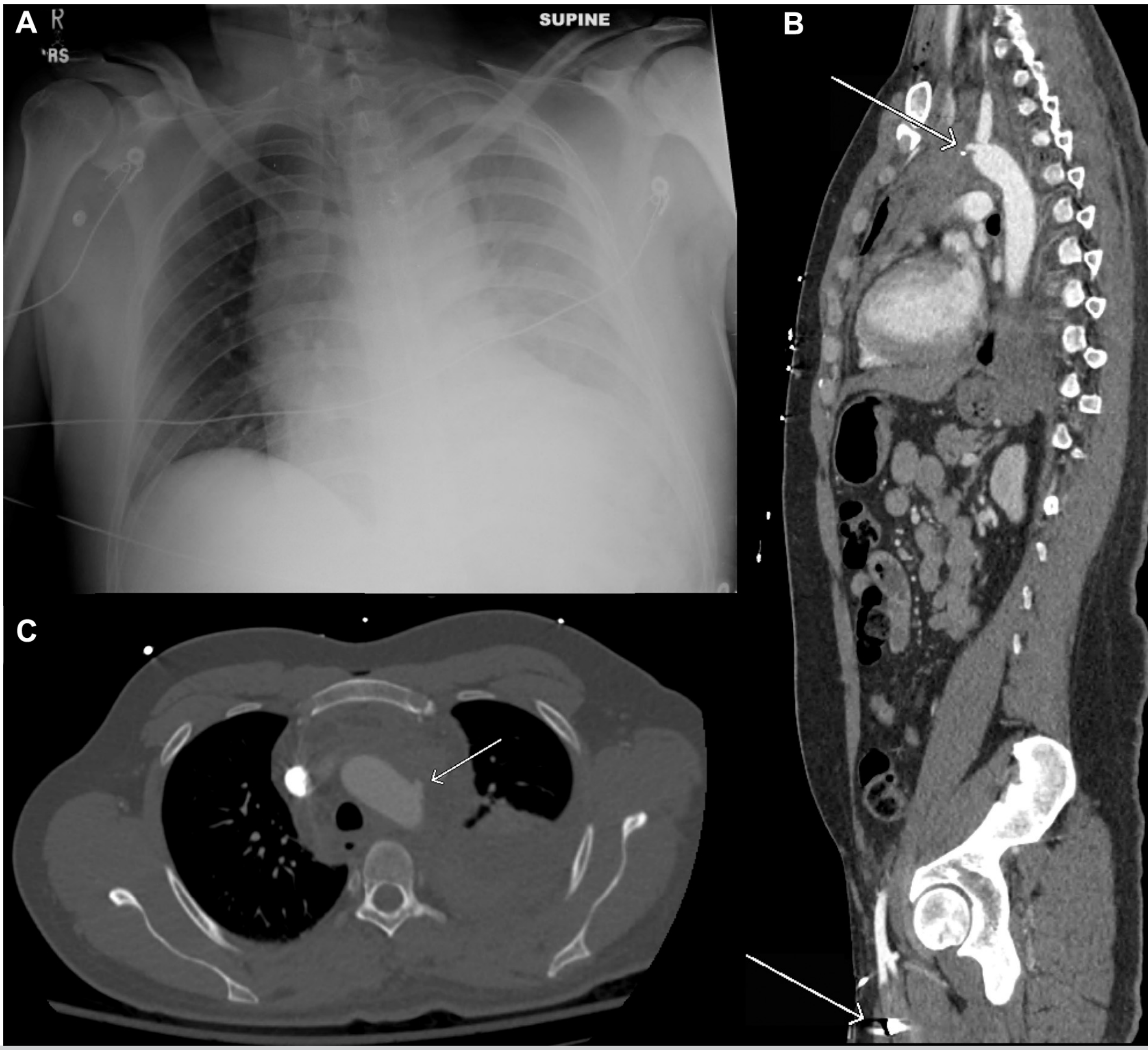

Fig 1. A, Chest radiograph demonstrating left hemothorax with no retained bullet. **B,** Sagittal reconstruction demonstrating aortic injury (*upper arrow*) and hyperdense object in left superficial femoral artery (SFA) with occlusion (*lower arrow*). **C,** Aortic injury proximal to left subclavian artery (*arrow*) with associated mediastinal hematoma and left hemothorax.

Angiography revealed left subclavian artery retrograde filling with type II endoleak into the area of injury (Fig 2, *A*). Therefore, a 12-mm Amplatzer Vascular Plug II (Abbott Laboratories, Abbott Park, Ill) was deployed into the proximal left subclavian artery through left brachial access without covering the left vertebral artery. Completion angiography from the left arm revealed exclusion of the endoleak (Fig 2, *B*). His blood pressure gradually worsened, and a left chest tube was then placed with evacuation of 500 mL of blood. He was then taken to the intensive care unit with a plan for left groin exploration after further resuscitation. Despite the foreign body in the SFA, anticoagulation was not started postoperatively given his hypotension, concerning for continued bleeding.

The patient was resuscitated and recovered well in the intensive care unit. His blood pressure was supported to maintain a mean arterial pressure above 80 mm Hg for 24 hours in the immediate postoperative period per our standard protocol to decrease the risk of spinal cord ischemia. There was no evidence of spinal cord ischemia, left arm ischemia, or left leg ischemia, and the patient regained a left radial pulse on postoperative day 2. Gastrografin esophagography was negative for esophageal injury, and bronchoscopy ruled out tracheal injury.

On return to the operating room, intraoperative ultrasound revealed a hyperechoic foreign body within the left SFA (Fig 3, *A*). A longitudinal skin incision was made over the left common femoral artery, extending to the SFA. The common femoral artery, SFA, and profunda femoris artery were circumferentially dissected and controlled. There was an obvious mass in the SFA and no palpable pulse distally (Fig 3, *B*). A transverse arteriotomy over the mass revealed the bullet embolus, which was removed and sent for ballistic evaluation as part of the police investigation (Fig 3, *C*). Fogarty balloon embolectomy proximally

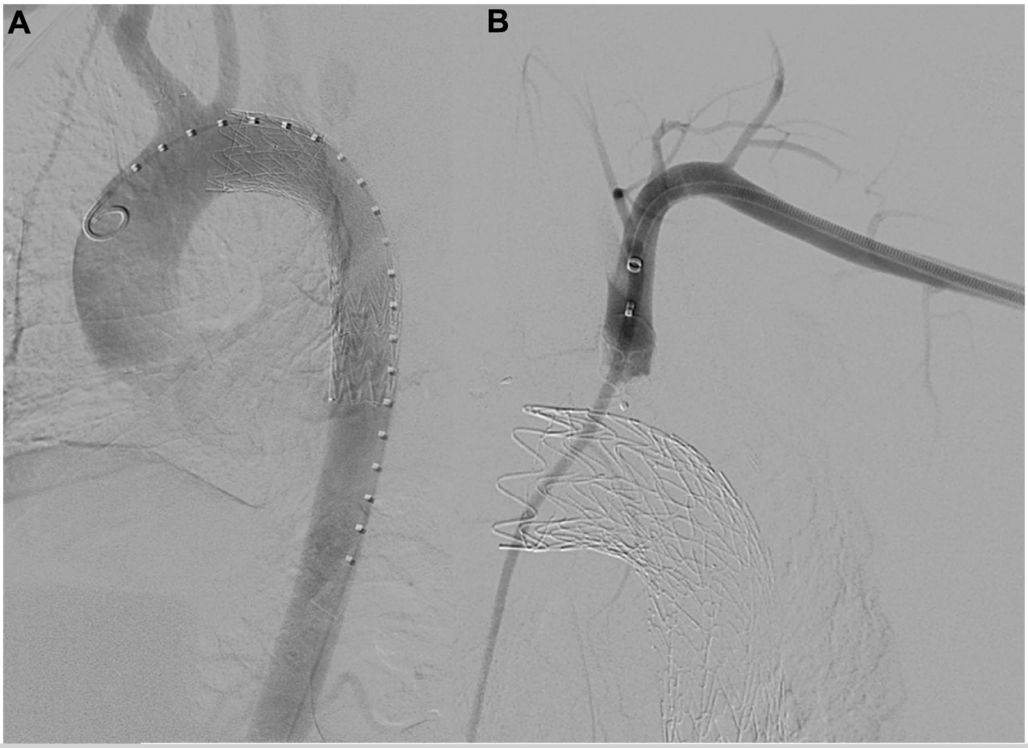

Fig 2. A, Angiogram after repair with type II endoleak and extravasation from aortic injury. **B,** Angiogram after left subclavian plug placement with exclusion of aortic injury and no endoleak.

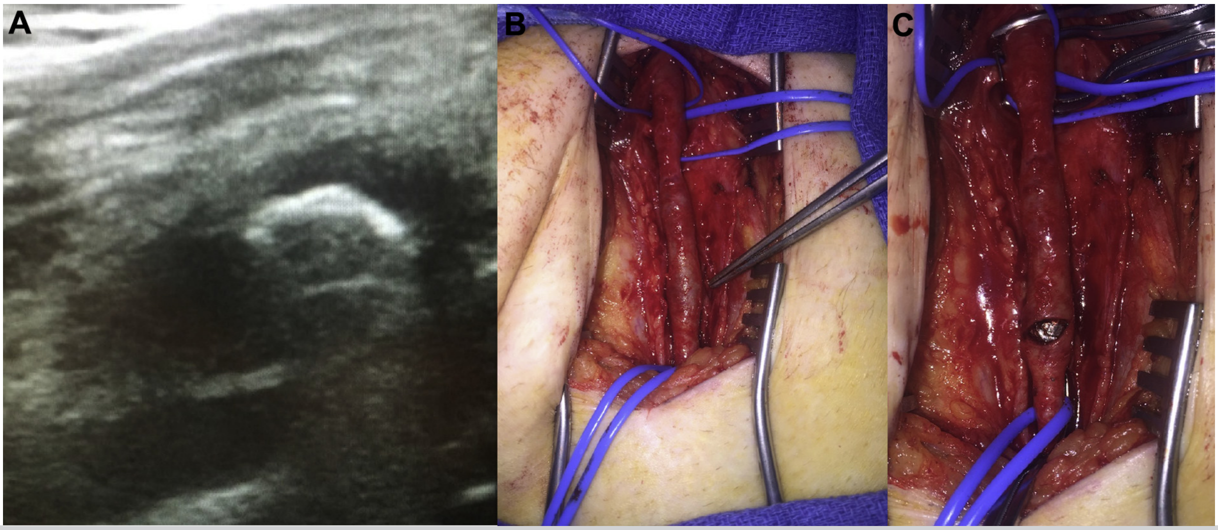

Fig 3. A, Ultrasound revealing hyperechoic foreign body in the superficial femoral artery (SFA). **B,** Exposure of left common femoral artery, SFA, and profunda femoris artery with intraluminal mass in SFA (forceps). **C,** Transverse arteriotomy demonstrating bullet embolus in the SFA.

and distally removed thrombus and restored pulsatile inflow and brisk backbleeding.

Distal pulses were not immediately regained after closure of the arteriotomy and release of the clamps, so on-table angiography was performed, demonstrating residual thrombus in the popliteal and tibial arteries (Fig 4, *A*). Additional embolectomy restored inline flow to the foot (Fig 4, *B* and *C*). Palpable pedal pulses returned the following day. The patient was prescribed aspirin and maintained on a low-dose heparin drip at 500 units/h for 48 hours postoperatively. Postoperative CTA revealed successful exclusion of the aortic arch injury with plug of the proximal left subclavian artery (Fig 5). The chest tube was removed on postoperative day 7, and he was discharged home on postoperative day 9 on aspirin alone.

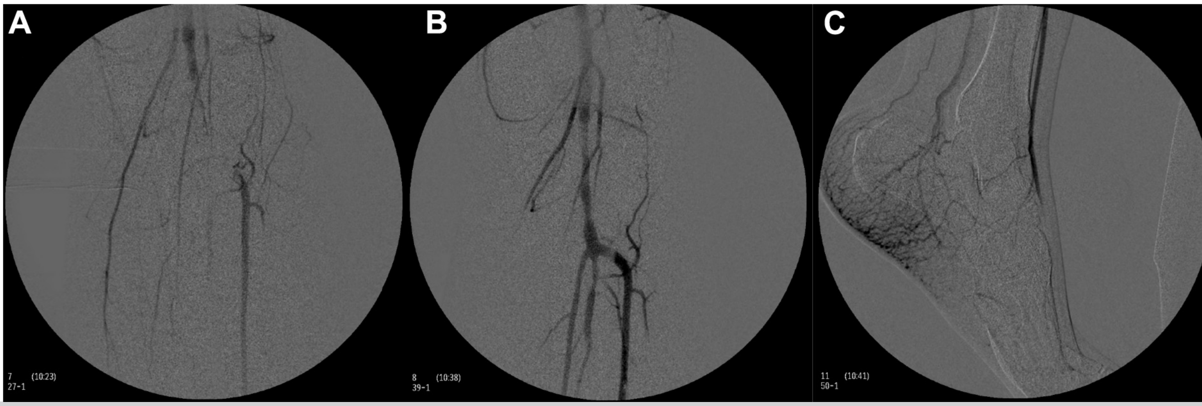

Fig 4. A, Angiogram with occlusion of distal popliteal artery and tibial arteries. **B,** Angiogram after embolectomy of popliteal and tibial arteries. **C,** Preserved runoff to pedal vessels.

Fig 5. Postoperative computed tomography angiography (CTA) demonstrating thoracic endovascular aortic repair (TEVAR) and left subclavian artery plug with no endoleak.

DISCUSSION

Bullet embolization, a rare consequence of firearm injury, is most commonly discovered on postmortem examination. For a projectile to embolize through the vascular system, it must exhaust all kinetic energy just after penetrating the vessel wall so that it comes to rest within the vessel lumen. Contributing factors include velocity and caliber of the projectile; low-velocity, small-caliber bullets are more likely than large-caliber, high-velocity bullets to dissipate all their energy within the body. In addition, the bullet diameter must be small enough to fit within the lumen of the vessel injured.[8]

Large studies of wartime injuries report that only 0.3% of 7500 vascular injuries during the Vietnam war and 1.1% of 346 injuries from the Afghanistan and Iraq wars presented with projectile emboli, many of which were sustained as fragments from explosions.[9,10] The incidence of arterial bullet emboli is estimated to be four times higher than that of venous emboli, probably because of the increased wall thickness of arteries.[9] For arterial emboli, >70% of bullets enter by penetrating the aorta or left cardiac chambers[2]; however, penetrating trauma to the thoracic aorta carries a mortality rate well above 90%.[1] Systemic bullet emboli most commonly lodge in the iliofemoral arteries (34%), carotid arteries (30%), and innominate and subclavian arteries (7%).[11] In case reports of bullet emboli to the lower extremity, the site of embolism is to the popliteal artery in 50% of cases.[4,12,13] When bullet emboli are observed in the lower extremity arteries, they are three times more likely to be found on the left than on the right side, presumably because the left common iliac artery branches more acutely (30 degrees) than the right common iliac artery (45 degrees).[5]

It is estimated that 10% of bullet emboli to peripheral arteries have an entry site within the venous circulation and embolize paradoxically through a traumatic arteriovenous fistula or a congenital patent foramen ovale.[14,15] Usually, projectiles that enter the venous system will migrate with blood flow to the central circulation, but 15% of venous bullet emboli will travel inferiorly by gravity, such as a report of a bullet entering the left subclavian vein and settling within the right popliteal vein.[14,16]

There are only four reports of bullet embolism in patients with gunshot wounds to the thoracic aorta in the last 20 years.[2,8,17,18] Olsun et al[17] reported a case of a "dummy" bullet penetrating the thoracic aorta with embolization to the right renal pelvis in a patient presenting with signs of cardiac tamponade. The aortic injury was surgically repaired with cardiopulmonary bypass, and the bullet was discovered incidentally on a postoperative radiograph. Pavy et al[18] reported a case of a 21-year-old man presenting with gunshot wound to the left thorax, hemothorax, and unilateral leg pain.

A bullet embolism to the popliteal artery was diagnosed by radiography, and he was treated with aortic stent graft implantation and open embolectomy. This case differs from ours in that the injury was to the distal descending thoracic aorta. The injury we describe was at the aortic arch, where repair is associated with more technical complexity, risk of stroke, and arm ischemia. Biswas et al[8] and Slobodan et al[2] each reported cases of bullet embolism to the popliteal artery found on radiography, but neither patient survived.

The diagnosis of arterial bullet embolism from projectile trauma begins with a thorough initial evaluation. An odd number of wounds implies a retained bullet, so the lack of identification of the foreign body in the bullet track on radiography should suggest bullet embolization. Thorough physical examination is critical as 66% of patients with arterial bullet embolism display signs and symptoms of ischemia, namely, limb weakness, decreased sensation, paresthesia, and diminished peripheral pulse.[14] The severity of symptoms depends on the collateral circulation, degree of existing atherosclerotic burden, and amount of time after the injury. Cases of bullet emboli have been found up to 80 days after the initial injury because the onset of symptomatic vascular insufficiency was delayed by progressive occlusion of the affected artery with distal thrombosis.[3] Confirmatory imaging by CTA, radiography, or ultrasound is necessary in asymptomatic patients when there is clinical suspicion.

Early surgical management of arterial bullet emboli is indicated to prevent progressive vascular insufficiency, especially to minimize the risk of amputation associated with intravascular bullets retained in major limb arteries.[19] Transverse arteriotomy and embolectomy are preferred, followed by careful examination of the integrity of the intima and balloon thrombectomy to remove distal thrombus. Angiography should be performed if palpable pulses are not promptly returned. Although endovascular retrieval has been described, open embolectomy is recommended to minimize damage to the intimal lining during extraction.[20]

Aortic injury and TEVAR. Bullet embolism is rarely an emergent problem, so initial management requires treatment of the life-threatening injuries caused by gunshot wounds to the thorax and zone 1 of the neck (sternal notch to cricoid cartilage). It is critical to rule out cardiac injury and pericardial tamponade with a focused assessment with sonography for trauma examination, followed by chest radiography to evaluate for hemopneumothorax, which should be treated with immediate tube thoracostomy. If the patient is hemodynamically stable without hard signs of vascular injury, CTA of the chest, abdomen, and pelvis can provide valuable information on the trajectory of the projectile and potential injuries to the great vessels, esophagus, trachea, and lungs.[21,22] Injuries to the great vessels are diagnosed on CTA of the chest in 5% of gunshot wounds to thorax.[23] Endoscopy to rule out injury to the trachea and esophagus should be considered.

In the United States, blunt thoracic aortic injury is substantially more common than penetrating aortic injury. Multiple prospective and retrospective cohort studies have shown the advantage of TEVAR over open repair of blunt traumatic aortic injury with lower overall mortality and lower rates of paraplegia, kidney injury, and infection.[7,24-26] In the largest meta-analysis of blunt thoracic aortic injury, Murad et al[27] found the mortality rate associated with endovascular repair to be 9% vs 19% with open repair. The Society for Vascular Surgery guidelines recommend endovascular repair of blunt thoracic aortic injuries if it is available over open repair.[6] These guidelines cannot be extrapolated to penetrating aortic injuries because patients rarely survive and endovascular options may not be immediately available. Nonetheless, if a contained aortic injury is seen on CTA and it is anatomically amenable to endovascular repair, this can be a lifesaving intervention if it is performed expeditiously.

CONCLUSIONS

Survival with discharge to home after a large-caliber bullet injury to the aortic arch with subsequent embolization is remarkable. Gunshot wounds to the thoracic aorta with associated bullet embolism are extremely rare because of the high mortality rate associated with the inciting injury. Methodical physical examination can often lead to the diagnosis. Management requires initial treatment of life-threatening injuries. In this case, the patient underwent emergent TEVAR for traumatic injury to the aortic arch with extravasation into the mediastinum and left hemithorax to prevent exsanguination, followed by delayed removal of the bullet embolism and discharge home with normal functional status.

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