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Brachiocephalic artery & subclavian vein injury with embolization to the pulmonary vasculature☆

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ABSTRACT

Penetrating trauma with resultant vascular injury can cause significant morbidity and mortality. In rare instances, embolization of projectiles or other foreign bodies can cause additional morbidity and present a diagnostic challenge to the treating physician. With the advent of endovascular stents, the use of minimally invasive techniques for the management of vascular injuries from penetrating trauma is increasing. We present the case of a brachiocephalic artery to subclavian vein arteriovenous fistula following a BB gunshot to the neck successfully treated with endovascular stent and non-operative management of a projectile embolus to the pulmonary arterial circulation.

Minimally invasive therapeutic modalities are an attractive approach for management of penetrating vascular trauma. These therapeutic approaches have not been studied extensively in the pediatric population. Morbidity and mortality associated with traditional surgical approaches can be safely avoided in select patients.

1. Case report

A 13-year-old male with no significant past medical history presented to our Level I trauma center after sustaining a penetrating injury from a BB gun to the right anterior neck. The patient complained of neck pain and intermittent shortness of breath. Blood pressure was 122/80, heart rate was 99 beats per minute, respiratory rate was 20 per minute and his oxygen saturation was 99% on room air. The patient's height and weight were 1.65 m and 46.9 kg respectively. Physical exam revealed a single 5 mm wound to the right anterior zone I of the neck. Lung sounds were clear and equal bilaterally and no additional external signs of trauma. Of note, there was no audible bruit, palpable thrill or hemoptysis.

An anteroposterior chest roentgenogram revealed a single BB projecting over the left mid-lung without evidence of pneumothorax or hemothorax. A computed tomography angiogram of the neck was obtained and was interpreted as negative for vascular injury by the trauma team and the interventional radiologist. There was also no evident trajectory of the BB through the soft tissues. The patient was admitted to the pediatric intensive care unit for airway monitoring and serial examinations.

The following day a new carotid bruit was identified on auscultation and the patient complained of dysphagia. A duplex ultrasound showed a small hematoma deep to the entrance wound without obvious evidence of vascular injury, and an esophagram was negative for injury. Persistence of the carotid bruit prompted a formal angiogram.

Using fluoroscopic guidance, the arterial access site was selected. Lidocaine was infused into the overlying soft tissues and right femoral artery access was obtained with single wall micropuncture technique. A 0.018 guidewire was advanced and using modified Seldinger technique the needle was exchanged for a dilator prior to placement of a 5 French vascular sheath over a 0.035 wire. A 5 French angled tapered glide catheter was inserted over a 0.035 inch guidewire into the right subclavian artery. A right subclavian arteriogram was performed which showed a traumatic fistula communicating with the right subclavian vein with opacification of the bilateral brachiocephalic veins and the superior vena cava. The left vertebral artery was then selectively catheterized and a left vertebral

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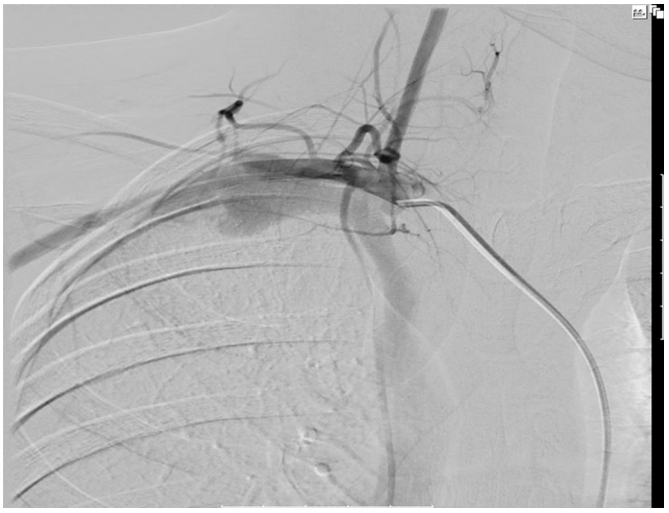

Fig. 1. Subclavian artery-subclavian vein arteriovenous fistula.

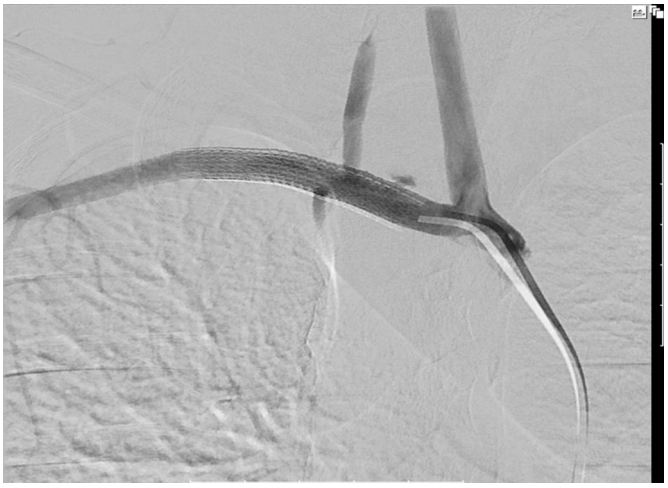

Fig. 3. Stent placement with endoleak.

arteriogram was performed including the posterior circulation which demonstrated a patent vessel with normal trajectory and good ipsilateral and contralateral flow including partial opacification of the right vertebral artery. The 5 French vascular sheath was then exchanged for an 8 French vascular sheath and the patient was given IV heparin. The right subclavian artery was again accessed and an 8 mm × 5 cm Gore® Viabahn® (W.L. Gore & Associates, Flagstaff, AZ) covered endoprosthesis was deployed. This was up sized compared to the vessel diameter. On subsequent imaging during the same procedure the AV fistula was no longer visualized, but it was noted that the thyrocervical trunk was covered by the stent graft. In addition a type I endoleak was identified. Balloon angioplasty was performed three times with arteriograms which showed persistence of the type I endoleak without fistula (Figs. 1–3). A type I endoleak can be managed by deploying additional graft at the site of the leak with the goal of covering the leak. In our patient, however, due to the close proximity of the problem area to the right common carotid and the minimal size of the leak no additional stent graft was placed proximally. We did continue to monitor the patient closely in the pediatric intensive care unit in case an additional intervention was required. The BB, which embolized from the right subclavian vein to the left pulmonary arterial circulation was left in place because the patient was asymptomatic. The patient continued to do well and he was discharged home with 81 mg of aspirin for three months due to presence of the endoprosthesis.

The patient was seen in clinic six months after the injury and a computed tomography angiogram of the chest was obtained to evaluate the stent graft and also to evaluate the BB which had been left in place. The BB remained in the left upper lobe pulmonary arterial circulation. The right subclavian artery was also evaluated and no endoleak was identified and no vascular obstruction or fistula was visualized. Due to concerns for repeated exposure to radiation and contrast media, the plan at this point was to evaluate on a yearly basis with physical exam and Duplex Doppler or arteriogram if needed. The patient missed his follow up appointment at eighteen months. However, he was successfully contacted at 23 months and reported no symptoms on telephone interview. Duplex Doppler at 23 months post-injury revealed widely patent subclavian, axillary, and brachial arteries with a widely patent stent within the subclavian artery. Normal high resistance biphasic waveforms were identified throughout the arterial system. The right internal jugular, subclavian, and brachial veins were patent with anechoic lumina and normal compressibility and augmentation.

Fig. 2. Stent placement.

2. Discussion

Since the first described report by Davis in 1834, intravascular migration of bullets is a rare complication of penetrating vascular trauma. A retrospective study of 7500 casualties during the Vietnam War revealed an incidence of 0.3% [1]. Migration of bullets or other foreign bodies can be arterial or venous, 80% and 20% respectively. Paradoxical embolization from venous to arterial circulation can also occur if there is a left to right shunt. Arterial emboli are usually discovered earlier than venous emboli as venous emboli can remain asymptomatic [2].

Identification of a bullet embolus can be a diagnostic challenge to the treating physician as the presentation can vary from completely asymptomatic to symptomatic with ischemia, neurologic deficit, abscess formation and other symptoms depending on the location of the embolus. However, an odd number of wounds, an unexpected location of the projectile based on trajectory, and gunshot wounds with vascular trauma are some of the findings that should raise suspicion for a bullet or foreign body embolus [3].

Due to the rarity of this complication the existing literature is based mainly on case reports and small case series. Correspondingly,

the management of this injury varies from institution to institution. Nevertheless, management strategies include endovascular retrieval of foreign bodies, operative removal, and non-operative management with close observation. It is generally accepted that a symptomatic projectile embolus should be removed either endovascularly or operatively [1–8]. Complications of non-operative management include claudication, paresthesias, abscess, infarction, gangrene, endocarditis, arrhythmias, and sepsis. However, asymptomatic emboli may be observed [2–4].

An additional challenge that is encountered when dealing with these injuries is that of long term follow up. Data regarding long term results of patients managed with endovascular techniques is limited in both adult and pediatric populations. There is data which suggests that patients are frequently lost to follow up unless they are experiencing problems as a result of their injury. In addition concern for exposure to radiation with computer tomography or contrast media with a formal angiogram further aggravate the difficulty of long-term follow up in a typically young patient population. Due to its non-invasive nature and lack of exposure to radiation, Duplex Doppler has become the preferred initial imaging modality for long term follow-up of these patients [9].

Huebner reported the case of a 54-year-old female who sustained shotgun pellet emboli to the pulmonary arteries following a left upper extremity gunshot wound with associated left brachial artery transection. This case was managed initially with a left subclavian artery to left brachial artery bypass using a left greater saphenous vein conduit. Subsequent repair with a left axillary artery to radial artery bypass with PTFE graft and radial and ulnar artery thrombectomies were performed following compromised vascular flow to the left upper extremity. During the hospitalization, migration of the pellets on x-rays prompted evaluation with CT angiography and multiple bilateral pulmonary emboli were identified. These were successfully managed with observation only [3].

Greaves and collaborators demonstrated successful non-operative management of a shotgun pellet embolus to the right ventricle from a left brachiocephalic vein injury following a drive by shooting. In this report the decision to withhold operative management was based on the patient being asymptomatic. This patient continued to do well at 6 months follow up [2].

Mattox et al. reported one of the largest case series from a single institution on the management of migratory bullets. In their experience of 28 patients, 20 underwent removal, and one patient had unsuccessful attempted removal from the carotid artery. Of the remaining 7 patients, 5 had emboli to the pulmonary arteries, 1 had an embolus to the hepatic vein and 1 had an embolus to the renal vein. These were successfully managed with observation alone [4].

Carter also exhibited the successful retrieval of a bullet embolus from the external to the common iliac vein with endovascular technique after operative repair of the iliac vein injury [5]. Fernandez-Ranvier et al. further demonstrated successful non-operative management of an embolus to the pulmonary artery from the left femoral vein with the patient remaining asymptomatic 4 years after injury [6]. On the other hand, Saltzstein described the operative management of a right axillary artery bullet embolus from a gunshot wound to the right ventricle and subsequent erosion through the interventricular septum. This particular patient was discharged from the hospital after treatment of a thoracic wound infection. No follow up data was provided [7].

Penetrating vascular trauma to the great vessels has a wide spectrum of presentation from patients *in extremis* or dead at the scene, to hemodynamically stable patients such as our case. Historically, these injuries have been managed operatively, however, the role of endovascular treatment is evolving and as experience with this modality grows, it is becoming an important management strategy for these injuries. DuBose et al. provide a comprehensive review of endovascular management of subclavian and axillary arterial injuries. In their study 56.3% of injuries were secondary to penetrating trauma, 21.3% secondary to blunt trauma, 21.8% due to iatrogenic catheter injury, and 0.6% were secondary to surgery. The injuries described in their series included pseudoaneurysm, arteriovenous fistula, occlusion, transection, perforation, and dissection. Initial management with endovascular stent was successful in 96.9% of patients. At follow-up to 70 months, endovascular stents had a 84.4% patency rate. 6.3% required a repeat endovascular therapy. Endoleak was present in 1.2% and occlusion requiring surgery in 0.6%. DuBose et al. point out that while there remains an uncertainty in patient selection and treatment algorithms, these early results are promising and further prospective data is needed to clarify the role of endovascular treatment for traumatic injury of the great vessels [8].

3. Conclusion

Bullet embolus is a rare and potentially serious complication of penetrating vascular trauma. Because of its rarity there is no established guideline for the management of this complication. In general symptomatic cases warrant retrieval with endovascular methods if available. Otherwise, operative retrieval and repair of injuries should be attempted. Asymptomatic cases may be safely observed. In addition endovascular management of vascular injuries is an evolving modality and further study is required to elucidate indications, appropriate patient selection, follow up methods and other nuances related to this therapeutic intervention. This is especially true in the pediatric patient population where limited data is available.

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