Endovascular Management of Upper and Lower Extremity Vascular Trauma

A series of case studies demonstrating the utility of endovascular techniques and tools to treat traumatically injured vessels in the extremities.

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Upper and lower extremity traumas are infrequently seen in the civilian health care system. Their frequency is significantly higher in military facilities during periods of armed conflict. The National Trauma Databank reported that 66% of traumas involve upper and lower extremities, and 18% of these (15% lower and 3.31% upper extremities) are Abbreviated Injury Scale > 3. Vascular injuries involving the extremities are rare, and in fact, only 26% of extremity traumas have vascular lesions. Extremity arterial injuries are a result of penetrating (stab or gunshot wounds) or blunt (traffic accidents, compressions) traumas and iatrogenic injuries. The main mechanisms of vascular lesions include laceration or rupture of the vessel, hematoma development, dissection, pseudoaneurysm or arteriovenous fistula formation, and distal acute ischemia.

In the past 2 decades, diagnostic angiography was used to identify arterial damage, but due to technological advancements, mutidetector computed tomography angiography (CTA) has essentially replaced traditional diagnostic angiography. Selective angiography is now reserved for the patients with suspected (previously detected through CTA) vascular injuries and are indicated for endovascular treatment.

A traumatic lesion of the main artery in extremities can be treated with bare-metal stent or stent graft placement, whereas distal branch bleeding can be embolized. Embolization can be performed with coils, vascular plugs, gelfoam pledgets, particles, liquid embolic (N-butyl cyanoacrylate and ethylene vinyl alcohol copolymer), or a combination of these. Endovascular treatment is a minimally invasive option and an alternative to open surgery, which avoids adjacent tissue damage and has potentially lower morbidity and mortality rates than conventional management.

The following cases demonstrate the importance of endovascular treatment for traumatic vascular injuries in the upper and lower extremities.

CASE 1: FEMORAL ARTERIAL INJURY EMBOLIZATION AFTER FEMORAL FRACTURE

Overview

A 45-year-old man was admitted to the emergency department after being hit by a car. The patient was in shock and hemodynamically unstable. Physical examination revealed a voluminous hematoma in the right thigh. X-rays showed a transverse, displaced fracture of the femur shaft (Figure 1A). The patient's hemodynamics worsened despite fluid and blood replacement. The patient was sent to the angiography suite for selective embolization and to stabilize his hemodynamic condition.

Procedure Description

Contralateral femoral arterial access was achieved with a 6-F sheath. Right femoral arteriography showed contrast extravasation from a lateral branch of the superficial femoral artery close to the fracture (Figure 1B). Superselective catheterization of the bleeding vessel was performed

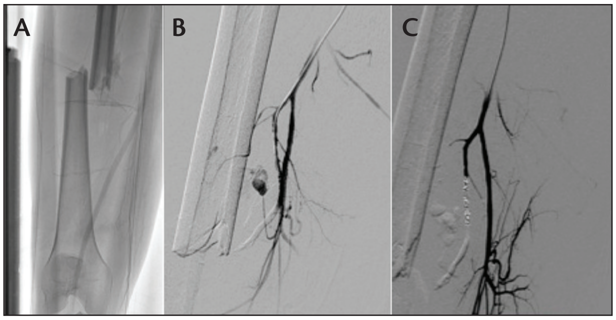

Figure 1. Femur x-ray demonstrating a transverse, displaced fracture of the femur shaft (A). Selective superficial femoral artery angiogram showing the source of the active bleeding next to the femoral fracture (B). Control angiogram after gelfoam and coil embolization (C).

with a coaxial system, using a 5-F diagnostic vertebral catheter, a high-flow microcatheter, and a 0.014-inch guidewire. Superselective embolization was performed with sterile gelatin sponge (gelfoam) administration and three Tornado coils (Cook Medical). Final control arteriography confirmed complete exclusion of the bleeding vessel (Figure 1C).

Discussion

During embolization, it is important to obtain a stable microcatheter position (for example, with a coaxial system) to avoid catheter "kick out" and nontargeted embolization. Correct vessel sizing is necessary to choose the appropriate coil dimension; if the size is too small for the vessel, the coil may migrate distally, and if it is too large, it may push the microcatheter back.

CASE 2: LARGE-VOLUME, DETACHABLE COIL EMBOLIZATION IN A RIGHT GLUTEAL HEMATOMA

Overview

An 85-year-old man presented at the emergency department for hypotension after gluteal trauma. The patient was lucid, and his general condition was rated as average. Physical examination revealed sensitivity and ecchymosis in the right gluteal region. CTA revealed a right gluteal hematoma, with active bleeding from the internal iliac artery and compression of the sciatic nerve (Figure 2A). The patient's hemodynamics worsened despite fluid and blood replacement. A multidisciplinary team decided to perform angiographic embolization, and the patient was sent to the interventional radiology department.

Procedure Description

Retrograde right common femoral arterial access was achieved with a 6-F sheath. Selective catheterization of

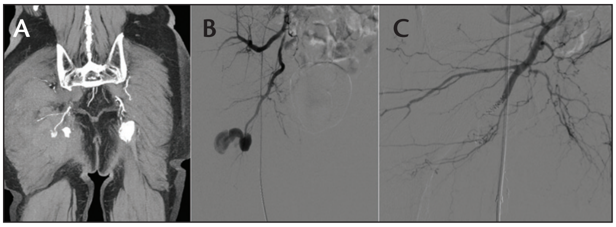

Figure 2. Coronal maximum-intensity projection reconstruction showing a right gluteal hematoma with active bleeding (A). A selective right internal iliac angiogram showing active bleeding from the inferior gluteal branch (B). Large detachable coils were deployed until no further contrast flow was seen (C).

the right hypogastric artery with a 5-F Simmons 1 catheter demonstrated the bleeding site from the inferior gluteal branch of the right internal iliac artery (Figure 2B). Superselective arteriography was performed with a 0.014-inch guidewire, and a coaxial microcatheter was positioned for coil embolization. The bleeding vessel was embolized using two large-volume, detachable Ruby coils (Penumbra, Inc.). Control angiography confirmed the complete embolization of the target vessel (Figure 2C). No ischemic sequelae were observed during the course of hospitalization.

Discussion

Detachable coils permit precise delivery and deployment, reducing the risk of catheter kick out, and they have the possibility to be retrieved in case of misplacement. The Ruby coils have diameters similar to the 0.035-inch coils, maintaining high-flow microcatheter compatibility. Thanks to their softness and complex shape, it is possible to push them to obtain good packing and permanent occlusion in a short time, which reduces the radiation dose.

CASE 3: POPLITEAL PSEUDOANEURYSM WITH ARTERIOVENOUS FISTULA

Overview

A 58-year-old man was admitted for endovascular repair of a right popliteal arteriovenous fistula after surgical repair of right popliteal aneurysm following a gunshot wound. The patient's right leg was swollen and warm. CTA showed the presence of a right popliteal pseudoaneurysm with an arteriovenous fistula (Figure 3A).

Procedure Description

Retrograde left common femoral arterial access was achieved with a 5-F sheath. A 4-F diagnostic catheter confirmed a voluminous right popliteal pseudoaneurysm with an arteriovenous fistula, which was characterized by direct contrast injection into the popliteal and femoral veins (Figure 3B). An 11-F, 90-cm sheath was positioned

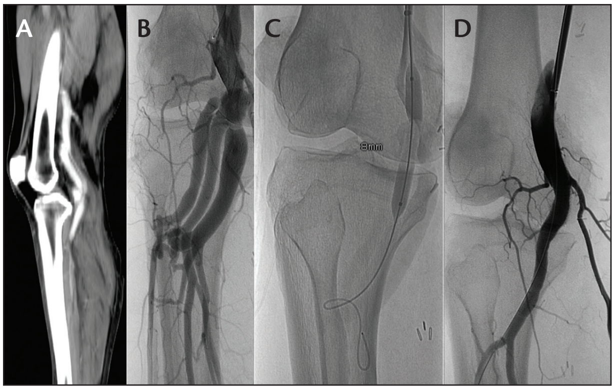

Figure 3. Sagittal CTA image showing a right popliteal pseudoaneurysm with arteriovenous fistula (A). An angiogram confirming voluminous popliteal pseudoaneurysm with direct contrast injection into the popliteal and femoral veins (B). Balloon occlusion test (C). A completion angiogram showing exclusion of the right popliteal pseudoaneurysm and the arteriovenous fistula while maintaining normal runoff of the vessels below the knee (D).

from a left femoral approach to the contralateral popliteal artery. A balloon occlusion test was performed (Figure 3C), and then the popliteal aneurysm and fistula were excluded with a 10-mm X 5-cm Hemobahn stent graft (Gore & Associates), which was dilated to 10 mm. Final control arteriography evidenced good popliteal pseudoaneurysm and arteriovenous fistula exclusion (Figure 3D).

Discussion

We performed a balloon occlusion test by inflating a soft balloon into the popliteal artery. With the balloon in place, we can control the distal flow and decide the most appropriate size of the stent graft to obtain complete exclusion from the arteriovenous fistula. Covered stent release allows the treatment of pseudoaneurysm while preserving distal arterial flow.

CASE 4: GELFOAM AND COIL EMBOLIZATION IN A THIGH HEMATOMA

Overview

A 72-year-old woman presented at the emergency department for a right thigh hematoma after a polytrauma. CTA showed a voluminous right anterolateral thigh hematoma, with diameters of 8 X 5 X 11 cm and evidence of active bleeding (Figure 4A).

Procedure Description

Retrograde contralateral common femoral arterial access was achieved with a 6-F sheath. Right iliac arteriography showed contrast extravasation from a

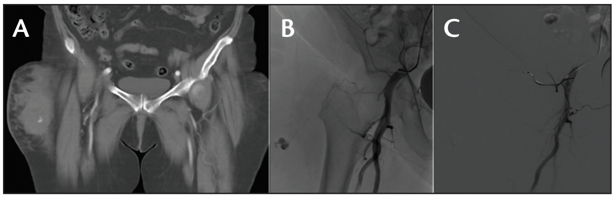

Figure 4. Coronal maximum-intensity projection reconstruction showing a large anterolateral thigh hematoma with active bleeding (A). A selective right iliac angiogram demonstrating a persistent blush of contrast from a branch of the deep iliac circumflex artery (B). Control angiogram after gelfoam and coil embolization (C).

branch of the deep iliac circumflex artery (Figure 4B). Superselective catheterization of the bleeding vessel was performed with a coaxial system, using a 5-F diagnostic vertebral catheter; a 2.8-F, 130-cm microcatheter; and a 0.014-inch guidewire. Superselective embolization was performed with gelatin sterile sponge (gelfoam) and one Axium detachable coil (Covidien). Final control arteriography confirmed good iliac hemostasis (Figure 4C).

Discussion

Gelfoam is a water-soluble and temporary embolic agent, which is completely absorbed by the body within 2 to 3 weeks. It is used to block arterial flow distally, and if mixed with contrast medium, you will be able to avoid uncontrolled reflux, quickly stopping the active hemorrhage. Distal target embolization is then followed by more proximal occlusion with coils.

CASE 5: STENT GRAFTING AFTER BRACHIAL ARTERY LACERATION

Overview

An 82-year-old man was admitted to the angiography suite for a large hematoma due to transection of the left brachial artery after an endovascular aneurysm repair. The left arm developed a voluminous bicipital hematoma, with distal pulse deficit and ischemia. The patient's hemodynamics worsened despite fluid replacement.

Procedure Description

Right common femoral arterial access was performed with an 8-F, 70-cm sheath. Left brachial arteriography showed massive contrast extravasation with unclear evidence of the distal part of the artery (Figure 5A). A coaxial system with a 5-F diagnostic catheter; a 2.8-F, 130-cm microcatheter; and 0.014-inch guidewire was used to regain the distal portion of the artery (Figure 5B). An injection from the 5-F diagnostic catheter confirmed the endoluminal position of the tip of the catheter. A 6- X 50-mm Viabahn covered stent (Gore & Associates) was

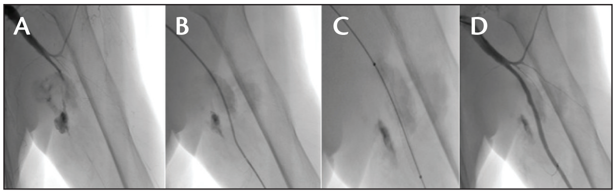

Figure 5. Left brachial angiogram showing active extravasation of contrast without filling of the distal vessels (A). Recanalization of the arterial transection with a 5-F diagnostic catheter (B). Stent graft deployment in correspondence to the brachial artery laceration (C). Control angiogram after stent graft release demonstrating cessation of arterial bleeding with good distal arterial flow (D).

deployed in the transected arterial segment (Figure 5C). The final control angiogram confirmed complete recanalization of the brachial artery (Figure 5D), and the patient was referred to a surgeon for hematoma evacuation in order to avoid a compartment syndrome.

Discussion

A stent graft can sometimes be the best option to stop arterial bleeding and replace the native vessel wall to restore flow in the distal tissues.

CASE 6: COILS AND ONYX LIQUID EMBOLIC SYSTEM (LES) EMBOLIZATION IN A THIGH HEMATOMA

Overview

A 67-year-old woman was admitted from another hospital for a thigh hematoma. CT showed a massive thigh hematoma with active bleeding from the left profunda femoral artery.

Procedure Description

Retrograde contralateral common femoral arterial access was performed with a 6-F sheath. Superselective catheterization of the bleeding vessels from the left profunda femoral artery was performed with a 0.014-inch guidewire and a microcatheter; the contrast injection showed a persistent blush (Figure 6A). Embolization of the bleeding vessels was performed using two 3-mm detachable Ruby coils and 0.25 mL of ethylene vinyl alcohol copolymer (Onyx LES 18, Covidien) (Figure 6B). Control angiography showed complete embolization of the target vessels (Figure 6C).

Discussion

Onyx LES is a nonadhesive liquid embolic agent that is made of ethylene vinyl alcohol copolymer, dimethyl sulfoxide solvent (DMSO), and tantalum powder. The speed of precipitation and solidification of the polymer depends on

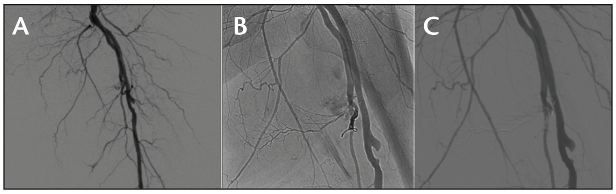

Figure 6. Selective angiogram showing a persistent blush of contrast from two branches of the left profunda femoral artery (A). Coils and Onyx LES 18 were deployed until no further contrast flow was demonstrated (B). Digital subtraction angiogram after coils and Onyx LES embolization showing successful exclusion of the bleeding vessels (C).

the concentration of copolymer dissolved in DMSO, which determines the viscosity of Onyx LES. There are three product formulations on the market: Onyx LES 18 (6% copolymer), Onyx LES 20 (6.5% copolymer), and Onyx LES 34 (8% copolymer), with different viscosities.

Some of the advantages of using Onyx LES include no risk for catheter gluing; slow, controlled, and intermittent injection; transembolization angiography; the ability to conform to the shape of tortuous arteries; and preservation of the option for subsequent surgical resection. However, there are some disadvantages associated with the agent, including the required use of a DMSO-compatible delivery microcatheter, possible embolization of parasitic feeders, pain during injection, the need for skilled operators, and high costs.

CONCLUSION

The endovascular approach can be a feasible, safe, and effective option to treat the vascular injuries in the upper and lower extremities, allowing for timely and minimally invasive management of peripheral active extravasation. Advances in endovascular materials and embolization agents permit a safe and rapid hemostasis in traumatic injuries. ■

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