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## Case report: Hybrid endovascular and open surgical approach to a chronic, traumatic arteriovenous fistula

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## 1. Introduction

The incidence of arteriovenous fistula (AVF) formation among all vascular injuries is 2.3% to 3.5%. Many of the smaller fistulae close spontaneously while others persist. These chronic fistulae are not always obvious, and when left to progress, they may result in cardiac, aneurysmal, and venolymphatic sequelae. Many approaches have been described using open surgical, endovascular, and hybrid techniques for treatment. We describe a case of a 53 year-old male with a symptomatic, chronic, traumatic AVF from a penetrating trauma 33 years ago, and its treatment by hybrid surgical technique.

## 2. Case presentation

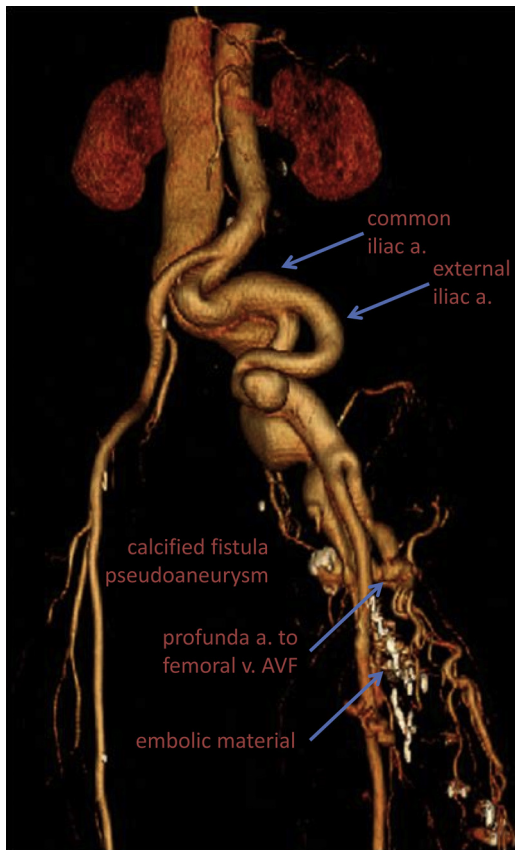
A 53 year-old male presented with an enlarging left thigh mass. A palpable thrill was noted in the thigh and calf. He experienced pain with ambulation, significant leg edema, and venous stasis skin changes below the knee consistent with venous hypertension. Thirty years ago, the patient reported being in a construction accident, in which a steel bar penetrated his upper left lateral thigh. The foreign object was removed and there was significant pulsatile bleeding, which was controlled with direct pressure. Except for a “machine” like vibration in his upper left thigh, he was asymptomatic for 30 years. He experienced mild edema of his left lower

extremity and brown skin changes below the knee three years ago, and began noticing thigh and calf pain with exertion.

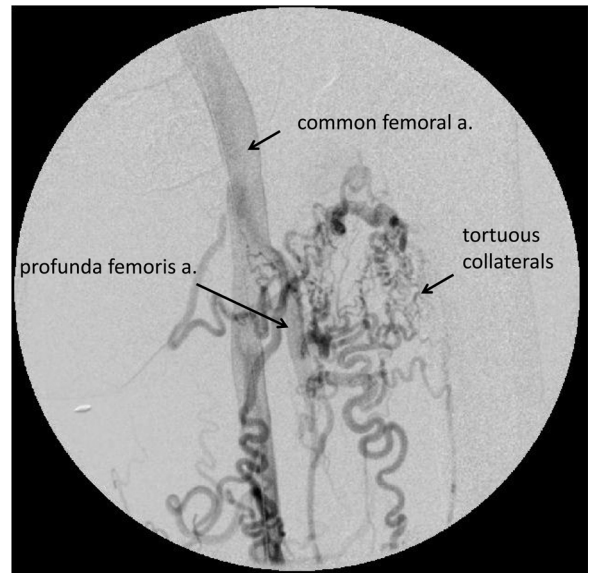
Three months prior to presentation, the mass enlarged and his claudication symptoms increased. Echocardiogram revealed cardiomegaly but no evidence of congestive heart failure or pulmonary hypertension. Ankle Brachial Indexes were normal. Doppler ultrasound of his lower extremity showed a dilated, tortuous left iliac artery, loss of obvious normal vascular anatomy, and a large groin AVF to profunda with numerous smaller venous AVFs. CT angiography was performed revealing a normal right iliac artery and vein, dilated and tortuous distal aorta, left iliac artery and vein, dilated SFA and profunda branches, large profunda to femoral vein (FV) AVF, extensive collateralization, and multiple smaller mid-thigh AVFs (Fig. 1). Digital subtraction angiography was performed in the operating room revealing the large 2.2 × 4.4 cm AVF of the proximal profunda to the FV. Given the patient’s young age, lack of commercially available peripheral stent graft with adequate diameter, and reluctance to use an aortic stent graft off label, we recommended an open repair (Fig. 2). Extensive fistulous collateralization of large profunda branches presented a challenge to conventional open ligation, and a two-staged hybrid approach consisting of endovascular embolization of the large fistulous collaterals was planned in order to avoid significant bleeding during an open intervention. The patient underwent coil embolization of all accessible AVF first in order to decrease the venous hypertension in preparation for an open ligation of the large left profunda to the femoral vein fistula. Access was attempted from the right side, however the left iliac artery was too tortuous to navigate. Therefore, access was obtained to the left femoral artery and the contralateral wire was snared from

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**Fig. 1.** CTA showing markedly ectatic and dilated common and external iliac arteries up to 2.9 cm, dilated common iliac up to 5.7 cm in diameter, large 2.2 cm wide by 4.4 cm long profunda AVF to femoral vein with a calcified fistula pseudoaneurysm, and multiple embolized smaller AVFs and collaterals. Also shown is a pseudoaneurysm at the left common femoral access site, which resolved on subsequent imaging.



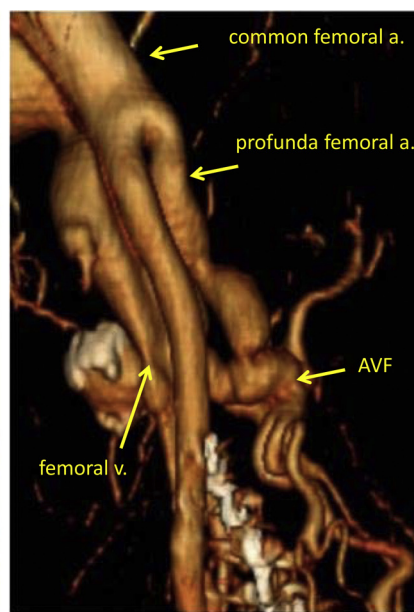
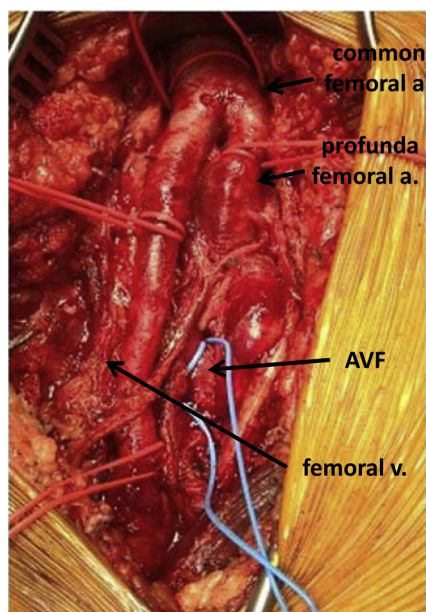
**Fig. 2.** Diagnostic digital subtraction angiogram revealing numerous, tortuous profunda collaterals.

Medical) coils ranging from 3–10 mm in size. The large 2.2 × 4.4 cm profunda AV fistula was visualized, but was confirmed to be too large for an Amplatzer™ plug (St. Jude Medical), Viabahn® covered stent (Gore Medical), or other endovascular intervention. The patient returned to the OR one week later for definitive profunda AVF exclusion with minimal venous bleeding and adequate vessel control despite a very difficult dissection (Fig. 3). The patient was followed for 16 months with resolution of his symptoms, decreased leg diameter, and control of venous hypertension. Follow up imaging at 1 year showed persistent occlusion of the AVF (Fig. 4).

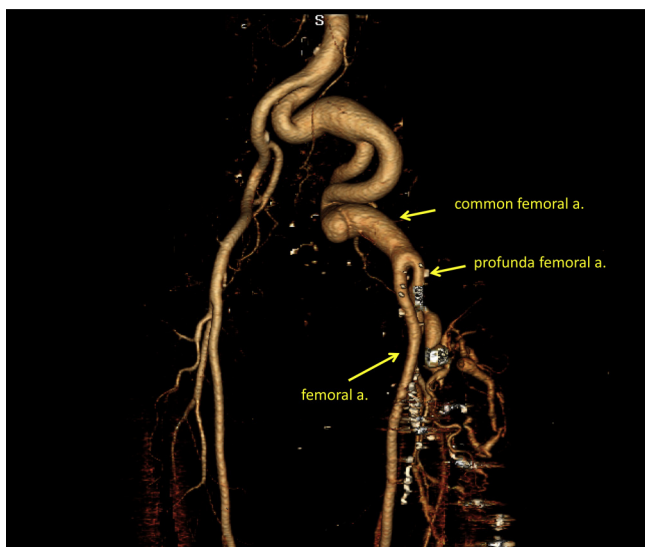
the right groin, effectively gaining antegrade access. The multiple fistulizing collaterals were selectively entered and coil-embolized with a total of 27 VortX™ (Boston Scientific) and Nester® (Cook

**3. Discussion**

The majority of experience with non-iatrogenic traumatic AVFs comes from the battlefield where most injuries are identified early. The non-war associated traumatic AVFs can present late after



**Fig. 3.** The findings on thigh exploration were consistent with CTA. Dilated and tortuous profunda artery dissected and blue vessel loop on the profunda to femoral vein.



**Fig. 4.** CTA at 18 months follow up showing persistent exclusion of the AVF by embolic material and stable aneurysmal changes.

trauma [1]. The delay in diagnosis of a chronic AVF is often due to a misdiagnosis as simple venous stasis. At times, the subtle sign of a continuous bruit or thrill can reveal a chronic AVF in patients receiving treatment for venous insufficiency [1–3].

The creation of an arteriovenous fistula by purpose or trauma causes a number of pathologic and physiologic changes with the associated vessels. Six to twelve months after creation, the artery proximal to the fistula can begin to dilate and elongate secondary to a dramatic increase in flow. If left untreated for five to ten years, the dilation of the inflow vessels may progress to aneurysmal changes [4,5].

Complications of untreated large chronic AVFs are common. Cardiac, aneurysmal, and venolymphatic changes can occur [5]. Complications include: thrombosis, infection, embolism, edema, rapid expansion, rupture, venous hypertension, pulmonary hypertension, and congestive heart failure. Most should be treated as prolonging intervention further exacerbates the complications and makes treatment more difficult [1,4,6].

Classically, traumatic AVFs were all repaired with open technique. In 1994, Marin et al., described the first series of endovascular treatment for arterial trauma [7]. With the advancement of endovascular technology, traumatic AVFs are being treated with thoracic endografts, Amplatzer plugs, coils, as well as covered stent grafts [8–11].

Non-iatrogenic traumatic AVFs should be approached on a individualized basis. Important considerations include: location, duration, and size. Peripheral and early fistulas can ideally be treated by endovascular treatment with stenting and/or embolization. The larger more long-standing fistulas may require a more sophisticated hybrid or multistage approaches [5,8]. Many of these older fistulas have developed the complications of venous hypertension or arterial aneurysmal disease. In our case, in the presence of numerous venous collaterals, multiple AVFs, and the large size of the primary profunda femoral fistula, the ideal approach was a staged hybrid intervention. Addressing the venous hypertension and gaining venous control by coil embolization helped reduce the potential bleeding that can be anticipated during open ligation of a long-

standing high flow AVF.

#### Conflicts of interest

The authors have no conflicts of interest to report.

#### Funding

There were no sources of funding for this work.

#### Ethical approval

No research is being reported in this study therefore no regulatory committee (e.g., IRB) approval was obtained.

#### Consent

The patient provided written, informed consent to access his medical record and publish his case report, including images.

#### Author contribution

Joseph Sabat, Sam Tyagi, and Shinichi Fukuhara authored the manuscript.

Behzad Farivar, Joseph Sabat, Sam Tyagi, and Tom Bernik performed the surgical procedures.

Alexander Kagen provided 3-D reconstruction of the images.

Tom Bernik is the surgeon who follows the patient.

#### Guarantor

Joseph Sabat and Tom Bernik are guarantors.

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