ORIGINAL ARTICLE

Management of traumatic arteriovenous fistulas: A tertiary academic center experience

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ABSTRACT

BACKGROUND: To present the surgical experience at a tertiary academic center of treating patients with traumatic arteriovenous fistulas (AVFs) who in whom endovascular treatment was contraindicated or in whom unsuccessful endovascular treatment had been performed.

METHODS: A total of 27 patients with traumatic AVFs who underwent surgery between September 2014 and May 2016 were included. The site of injury, timing of surgery, and the surgical methods utilized were analyzed retrospectively.

RESULTS: Arteriovenous fistulas were located in the lower extremity in 26 patients (96.29%) and in the upper extremity in one patient (3.7%). Etiological factors included gunshot injuries in 23 patients (85.18%) and penetrating injury in four patients (14.81%). AVFs in the lower extremity were between the popliteal artery and vein in 21 patients and between the femoral artery and vein in five patients. The one patient with upper-extremity AVF had a communication between the brachial artery and cephalic vein. Primary repair of the artery and vein after ligation, arterial graft interposition plus primary vein repair, and arterial and venous graft interposition were performed for surgical repair in two, five, and 20 patients, respectively. The saphenous vein was used for grafting in all cases needing grafts.

CONCLUSION: In patients enduring penetrating trauma in the close vicinity of major vascular structures, a detailed history-taking and physical examination should be performed along with auscultation. The endovascular approach may represent the initial choice of management because of its lower rate of complications, noninvasive nature, decreased in-hospital costs, and decreased loss of work productivity. However, surgery is still unavoidable option in a significant proportion of patients who are either hemodynamically unstable, contraindicated for endovascular treatment, or in whom endovascular treatment was unsuccessful.

Keywords: Arteriovenous fistulas (AVFs); endovascular treatment; surgical treatment; traumatic.

INTRODUCTION

Arteriovenous fistula (AVF) was first described as a medical entity by William Hunter in 1757, followed by the first surgical attempt at its correction in 1837 by Breschet, who tried to eliminate the fistula via ligation of the proximal artery.[1] Various factors play role in the etiology of traumatic AVF, the incidence of which is difficult to determine because of the possibility of delay in diagnosis up to years.[2,3] Absence of spontaneous regression within a 2-week period is an indication for endovascular or surgical management of AVFs.[4] Surgery may involve direct primary repair or anatomical reconstruction (repair with autogenous venous graft, autogenous or synthetic graft interposition, or bypass).

MATERIALS AND METHODS

A total of 27 male patients (mean age 37.58 years, range: 18–52 years) treated surgically in our cardiovascular unit for traumatic AVF between September 2014 and May 2016 were

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included in this study. Patient data were retrieved through a retrospective case record search. The etiology involved a gunshot fire in 23 patients (85.18%) and penetrating injury in four (14.81%).

The diagnosis was established following hemodynamic instability after trauma in seven patients. The remaining patients had been initially treated in other health facilities without presenting with hematoma formation or absence of pulses, and had been discharged after hemodynamic stability was attained.

AVF diagnosis was primarily on the basis of physical examination and the results of color Doppler ultrasound. In all seven patients undergoing emergency surgery for treating hemodynamic instability, an anatomical assessment was performed using computed tomography (CT) angiography. In other subjects, angiography was performed for anatomical assessment as well as for endovascular treatment.

RESULTS

In all patients, a murmur could be heard on auscultation and a thrill could be palpated over the fistula. Twenty patients had edema and venous dilation in the involved lower extremity, whereas AVF was accompanied by a pseudoaneurysm in four. Three patients had signs of cardiac failure. Femur fracture was present in three patients; all these patients were treated with external fixator and skeletal traction after orthopedic consultation.

In the lower extremity, AVF was located between the popliteal artery and vein in 21 cases, and between the femoral artery and vein in five. The only patient with upper-extremity AVF had a communication between the brachial artery and cephalic vein (Table 1). Except for the seven cases requiring emergency surgery for treating hemodynamic instability, the most frequent cause of unsuccessful endovascular treatment was the inability to advance the guidewire in 14 patients (51.85%). In one patient, emergency surgery was required for treating stent migration (Figs. 1, 2). Elective operations were performed between 1 and 26 months after the initial trauma and the mean operation time after trauma was 16±8 months.

Patients were prepared for surgery after anesthesia appropriate for the site of injury was provided. While approaching the site of AVFs, the artery was accessed both proximally and distally. Following systemic heparinization (100 IU/kg), arterial and venous clamps were placed both proximally and distally. In two cases, ligation and primary arterial and venous repair was possible. Other subjects were contraindicated for primary repair because of large defects underwent graft interposition of the artery and primary repair of the vein (n=5) or arterial and venous graft interposition (n=20). In cases with pseudoaneurysms, the sac was exposed after proximal and distal inspection, and the AVF was accessed. The saphenous vein

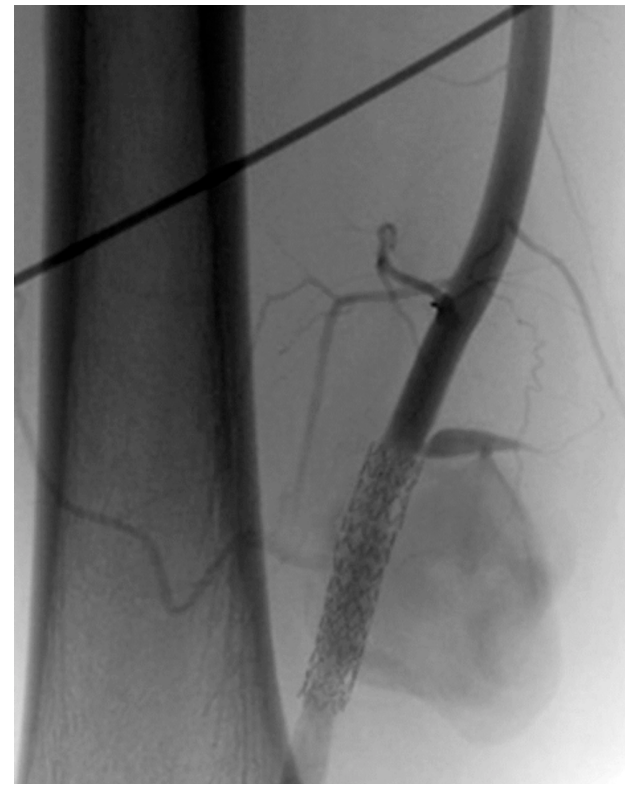

Figure 1. Angiographic image showing the stent migration during endovascular procedure.

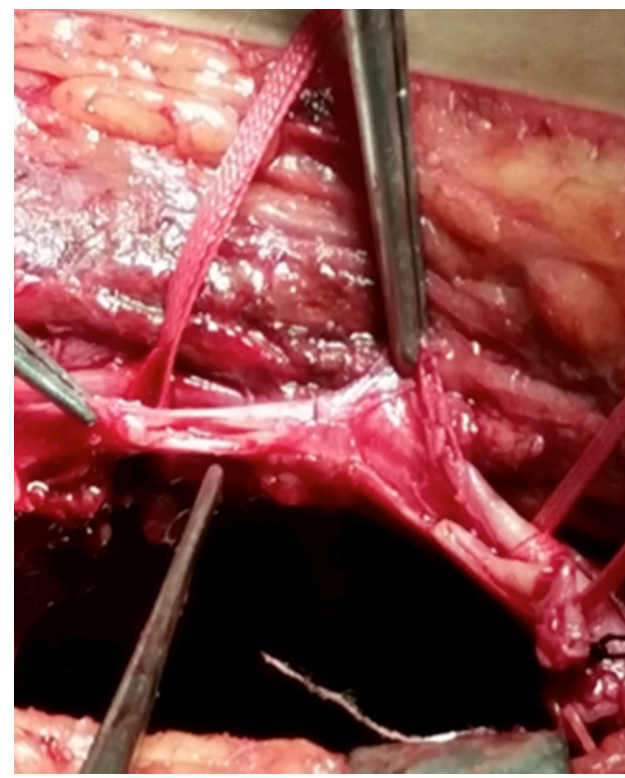

Figure 2. The image of the stent slipping during the procedure.

was used in all patients requiring grafting. In patients in whom emergency surgery was performed we evaluated the quality of saphenous vein with surgeon experience considering tortious

Table 1. Clinical properties of the patients

Injury etiology	Patient no	Age	Sex	Location	Symptom
Gunshot	1	45	Male	Popliteal artery-Popliteal vein	Leg edema
Gunshot	2	58	Male	Popliteal artery-Popliteal vein	Leg edema
Gunshot	3	37	Male	Femoral artery-Femoral vein	Hemodynamic instability
Gunshot	5	43	Male	Femoral artery-Femoral vein	Leg edema + heart failure
Gunshot	6	28	Male	Popliteal artery-Popliteal vein	Leg edema
Gunshot	7	37	Male	Femoral artery-Femoral vein	Leg edema
Gunshot	10	18	Male	Popliteal artery-Popliteal vein	Hemodynamic instability
Gunshot	11	27	Male	Popliteal artery-Popliteal vein	Hemodynamic instability
Gunshot	12	35	Male	Popliteal artery-Popliteal vein	Leg edema
Gunshot	13	44	Male	Popliteal artery-Popliteal vein	Leg edema
Gunshot	15	26	Male	Popliteal artery-Popliteal vein	Leg edema
Gunshot	16	44	Male	Femoral artery-Femoral vein	Leg edema
Gunshot	17	50	Male	Popliteal artery-Popliteal vein	Leg edema + heart failure
Gunshot	18	35	Male	Popliteal artery-Popliteal vein	Hemodynamic instability
Gunshot	19	38	Male	Popliteal artery-Popliteal vein	Leg edema
Gunshot	20	41	Male	Popliteal artery-Popliteal vein	Leg edema
Gunshot	21	39	Male	Popliteal artery-Popliteal vein	Hemodynamic instability
Gunshot	22	37	Male	Popliteal artery-Popliteal vein	Leg edema
Gunshot	23	30	Male	Popliteal artery-Popliteal vein	Hemodynamic instability
Gunshot	24	43	Male	Popliteal artery-Popliteal vein	Leg edema
Gunshot	25	38	Male	Popliteal artery-Popliteal vein	Leg edema
Gunshot	26	37	Male	Popliteal artery-Popliteal vein	Hemodynamic instability
Gunshot	27	39	Male	Popliteal artery-Popliteal vein	Leg edema
Penetrating	4	25	Male	Brachial artery-Cephalic vein	Leg edema
Penetrating	8	49	Male	Popliteal artery-Popliteal vein	Leg edema
Penetrating	9	52	Male	Popliteal artery-Popliteal vein	Leg edema+ heart failure
Penetrating	14	21	Male	Femoral artery-Femoral vein	Leg edema

structure of saphenous vein, hyperthermıa and presence of skin disorder (ulcer or dermatitis) around saphenous vein. In elective cases, we routinely used Doppler ultrasound to assess saphenous ven wall thickness, saphenous vein insufficiency, and presence of thrombophlebitis. We used saphenous vein of 3–8-mm diameter, without insufficiency and thrombophlebitis. In postoperative period, all patients received 100 mg of acetyl salicylic acid. No patient had postoperative venous thrombosis. All patients were discharged within a mean duration of 3 days (2.23±1.52) without complications. In follow-ups, success of surgery and healing of AVF was checked with Doppler ultrasound at 1, 6, and 12 months after surgery. No morbidity or mortality was recorded (Table 2).

DISCUSSION

Traumatic AVFs generally occur at anatomical sites where an artery is paired by or is in close vicinity of a vein. The most common etiological factors include gunshot injuries, penetrating injuries, or fractures. More than half of all traumatic AVFs occur in the lower extremity. Of these, 29% and 16% have been reported to involve the femoral artery and the popliteal artery, respectively.[5] Among our 27 participants, 26 had a lower-extremity AVF.

History and physical examination suffice for a diagnosis of traumatic AVF in almost all cases. Physical examination findings are generally typical, and involve a palpable thrill and continous murmur on auscultation. Additional physical examination findings may include the signs of chronic venous stasis such as ulceration, pigmentation, edema, and varicose veins. In addition, increase in skin temperature may be detected proximal and distal to the fistula. Signs of cardiac failure may also guide the physician in establishing the diagnosis. Depending on the size and localization of the fistula, congestive cardiac failure may also develop. Major systemic effects include increases in cardiac output, total blood volume, venous pressure, and heart rate along with cardiomegaly.[6]

Table 2. Surgical indications and procedures

Patient no	Surgical indication	Procedure
1	Failure to advance guidewire	Saphenous vein interposition to artery and vein
2	Failure to advance guidewire	Saphenous vein interposition to artery and vein
3	Hemodynamic instability	Saphenous vein interposition to artery + primary venous repair
4	Failure to advance guidewire	Primary repair
5	Failure to advance guidewire	Saphenous vein interposition to artery + primary venous repair
6	Highly mobile lesion site	Saphenous vein interposition to artery and vein + pseudoaneurysm repair
7	Highly mobile lesion site	Saphenous vein interposition to artery + primary venous repair + pseudoaneurysm repair
8	Failure to advance guidewire	Saphenous vein interposition to artery and vein
9	Highly mobile lesion site	Saphenous vein interposition to artery and vein
10	Hemodynamic instability	Saphenous vein interposition to artery and vein
11	Hemodynamic instability	Saphenous vein interposition to artery and vein
12	Highly mobile lesion site	Saphenous vein interposition to artery and vein + pseudoaneurysm repair
13	Failure to advance guidewire	Primary repair
14	Failure to advance guidewire	Saphenous vein interposition to artery + primary venous repair + pseudoaneurysm repair
15	Stent migration	Saphenous vein interposition to artery and vein
16	Failure to advance guidewire	Saphenous vein interposition to artery + primary venous repair
17	Failure to advance guidewire	Saphenous vein interposition to artery and vein
18	Hemodynamic instability	Saphenous vein interposition to artery and vein
19	Highly mobile lesion site	Saphenous vein interposition to artery and vein
20	Failure to advance guidewire	Saphenous vein interposition to artery and vein
21	Hemodynamic instability	Saphenous vein interposition to artery and vein
22	Failure to advance guidewire	Saphenous vein interposition to artery and vein
23	Hemodynamic instability	Saphenous vein interposition to artery and vein
24	Hemodynamic instability	Saphenous vein interposition to artery and vein
25	Failure to advance guidewire	Saphenous vein interposition to artery and vein
26	Failure to advance guidewire	Saphenous vein interposition to artery and vein
27	Failure to advance guidewire	Saphenous vein interposition to artery and vein

Angiography is the most accurate diagnostic modality for localizing the fistula, identifying its communications, and obtaining data on fistula hemodynamics. Noninvasive diagnostic techniques may be utilized for assessing smaller AVFs, measuring shunt volume, and identifying the degree of peripheral ischemia owing to distal steal effect.[7] In our patients, fistulas were diagnosed on the basis of the findings of physical examination and subsequent Doppler ultrasound assessment. In seven patients with hemodynamic instability, CT angiography was performed for anatomical assessment. In the remaining patients, angiography was used for anatomical assessment and therapeutic intervention.

Therapeutic options include surgery and endovascular intervention (coated stent graft or coil embolization).[7] Although, endovascular interventions were preferred, less-invasive procedures offer shorter hospitalization period, lower treatment cost, and lower complication rates.[8,9] Open surgery is still unavoidable option in a significant proportion of patients who are either hemodynamically unstable or contraindicated for endovascular treatment, or in those where endovascular treatment was unsuccessful.[10,11] In addition, in some cases, open surgery is unavoidable in highly mobile anatomical sites or when the procedure is unsuccessful occurs because of the inability to further advance the guidewire. Patency rates reported for AVF stent graft repairs at 1 year vary between 88 and 100%.[12,13] In present study, we achieved 100% patency rate at the sixth month after operation and we concluded that open surgical repair is still a valuable option for the management of AVF.

Indications for surgery generally include hemodynamically unstable or life-threatening lesions, availability of an experienced surgical team, injury in adjacent tissues (e.g., muscles, nerves), lesions contraindicated for endovascular treatment, and prior unsuccessful endovascular treatment.[8–11] The most frequent type of indication for surgery in our group was unsuccessful endovascular intervention, resulting from to inability to fur-

ther advance the guidewire in 14 patients, whereas surgery was performed for slipping in one, hemodynamic instability in seven, and fistula localization at a highly mobile anatomical region in five other patients.

Graft interposition should be surgically undertaken in patients who are contraindicated for surgical primary repair. The saphenous vein should be used for grafting whenever possible. Accordingly, the saphenous vein was used for the continuity of both the vein and artery in all of our patients requiring grafting. The average time to discharge was 3 days, with no morbidity or mortality. Moreover, at 1-year follow-up assessments, both veins and arteries were found to be patent.

In conclusion, endovascular treatment may be considered to represent as preferred treatment option in AVFs owing to a number of advantages. However, hemodynamically unstable patients, absence of a skilled surgical team or appropriate equipment, lesions contraindicated for endovascular interventions, or unsuccessful endovascular treatment remain common indications for surgery, which may be accomplished with high success rates.

Conflict of interest: None declared.

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ORİJİNAL ÇALIŞMA - *ÖZET*

Travma sonrası gelişen arteriyovenöz fistüllerin tedavisi: Üçüncü basamak akademik merkez deneyimi

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AMAÇ: Bu çalışmada, kardiyoloji ünitemizde gerçekleştirilen endovasküler tedavide başarısız olan, travmatik arteriovenöz fistüllü (AVF) hastalarda cerrahi deneyimimizi sunmayı amaçladık.

GEREÇ VE YÖNTEM: Eylül 2014–Mayıs 2016 tarihleri arasında travmatik AVF'si olan toplam 27 hasta ameliyat edildi. Yaralanma yeri, cerrahi zamanlaması ve kullanılan cerrahi yöntemler geriye dönük olarak incelendi.

BULGULAR: Arteriyovenöz fistüller alt ekstremitede 26 hastada (%96.29), üst ekstremitede tek bir olguda (%3.7) bulundu. Etiyolojik faktörler 23 hastada (%85.18) ateşli silah yaralanması ve dört hastada (%14.81) penetran yaralanma idi. Alt ekstremitedeki AVF'ler, 21 hastada popliteal arter ve ven arasında, beş hastada femoral arter ile ven arasında idi. Üst ekstremite AVF'li tek olguda brakiyal arter ve sefalik ven arasında iletişim vardı. Cerrahi onarım için ligasyondan sonra arter ve venin primer onarımı, arteriyel greft interpozisyon artı primer ven tamiri ve arteryal ve venöz greft interpozisyonu iki, beş ve 20 hastada gerçekleştirildi. Tüm olgularda safen ven greft olarak kullanıldı.

TARTIŞMA: Majör vasküler yapıların yakınında penetran travmalara maruz kalan hastalarda oskültasyon ile birlikte ayrıntılı öykü alma ve fizik muayene yapılmalıdır. Arteriyovenöz fistüller cerrahi olarak veya endovasküler girişimle (kaplı stent greft veya embolizasyon) tedavi edilebilir. Son yaklaşım, daha düşük komplikasyon oranları, prosedürün invaziv olmayan doğası ve hastane içi maliyetlerin azalması ve iş verimliliğinde azalma temel alınarak ilk tercih yönetimini temsil edebilir. Bununla birlikte hemodinamik olarak kararsız, endovasküler tedavi için uygulanabilir olmayan veya endovasküler tedavinin başarısız olduğu hastaların önemli bir bölümünde ameliyat kaçınılmazdır.

Anahtar sözcükler: Arteryovenöz fistüller; cerrahi tedavi; endovasküler tedavi; travmatik.

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