Arterio Venous Fistula

Dr

Esmael Ali Hamed

Vascular surgery specialist

- **An arteriovenous fistula (AVF)** is an abnormal connection between an artery and a vein.

- The earliest description of an arteriovenous fistula is credited to William Hunter, who in 1761 reported two patients with brachial AVFs following attempted phlebotomy.

- He also described the adaptive changes that accompany a communication between the brachial artery and vein: enlargement of the artery proximal to the AVF and a weak pulse below the lesion.

- What Hunter described were the most common physiologic effects of an AVF on involved arteries and the most appreciated sign of AVFs on physical examination, a thrill.

- AVFs remained uncommon until the 19th century, when the introduction of high-speed projectiles changed the magnitude and complexity of military injuries. Successive military conflicts and the increase in penetrating trauma among civilians resulted in a greater number of vascular injuries and, as a consequence, AVFs.

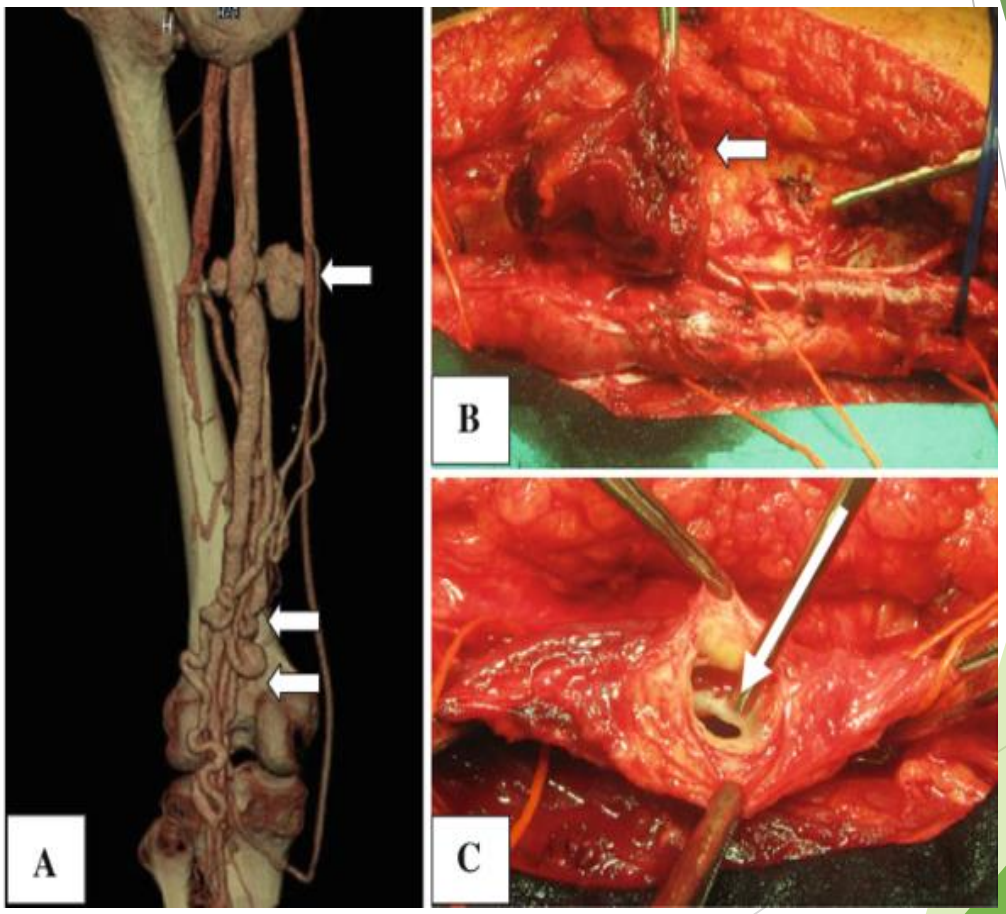
- However, prompt evacuation of victims from the battlefield, more effective resuscitation, and direct arterial and venous repair of injuries, begun during the Korean War and refined during the Vietnam and Iraq conflicts, have significantly reduced the number of traumatic AVFs encountered despite the increase in the incidence of penetrating vascular injuries.

ETIOLOGY AND INCIDENCE:

- The primary etiologies of acquired AVFs are traumatic injuries and iatrogenic injuries. A small number occur spontaneously, usually from erosion of an aneurysm into an adjacent vein.
- Iatrogenic Injuries: The increase in numbers of interventional procedures (both vascular and nonvascular) performed over the past 10 years has resulted in an increase in the complication of iatrogenic AVFs.

- Spontaneously Acquired AVF: Inflammatory processes and pathologic changes to the arterial wall have contributed to the development of spontaneously acquired AVFs. First described by Syme in 1831, spontaneous rupture of an aortic or iliac aneurysm or erosion of an inflammatory or mycotic aneurysm into a contiguous vein.

Fig. 5 Superficial femoral traumatic arteriovenous (AV) fistula had developed 7 years before due to a gunshot injury. **a** Multislice computed tomography (MSCT) (single white *arrow* shows AV communications; *double white arrows* indicate secondary developed superficial vein varices. **b** Intraoperative photograph shows the AV aneurysm (*arrow*). **c** AV communication (*arrow*) is apparent after opening the aneurysm sac

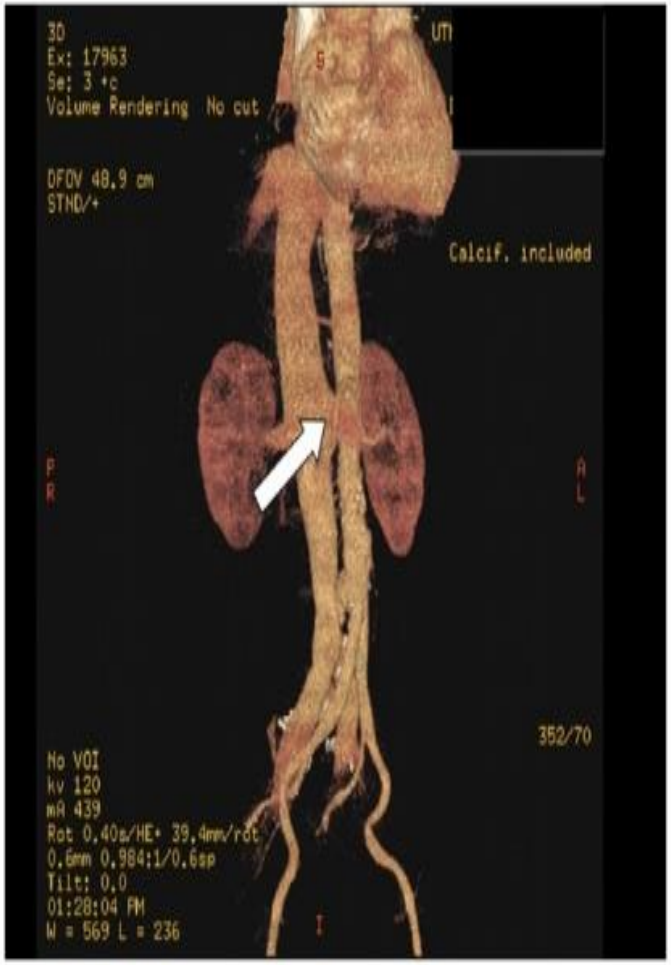


- In contrast, AVFs are less commonly associated with penetrating axillary artery injuries than with subclavian trauma, with only one AVF identified in a review of 85 penetrating axillary artery injuries.

- Central venous catheterization and therapeutic catheter manipulations to treat dialysis access–related complications may also be complicated by subclavian and axillary AVFs.

SITES:

- Subclavian
- Aortoiliac
- Aortocaval
- Femoral
- Popliteal
- Tibioperoneal
- Renal
- Hepatic
- Splenic
- Mesentric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PATHOPHYSIOLOGY:

A clear understanding of the hemodynamic and structural changes induced by AVFs is critical in recognizing the local and systemic manifestations and initiating appropriate treatments for AVFs.

The natural history of a communication between an artery and its contiguous vein is determined by the diameters of the artery and vein, the size and location of the fistula, the adequacy of the collateral circulation, and the competence of the valves in the distal veins.

Although some fistulae reduce in size, or even close spontaneously, a large number of fistulae become more prominent over time with larger communications as a result of degenerative changes in the arterial wall.

- Fistula Size and Flow: "The relationship between the size of the fistula and direction of flow has been elegantly demonstrated by Holman and Taylor, who found that the direction of flow in the distal artery is maintained when the cross-sectional area of the fistula is equal to or less than 1.5 times the diameter of the inflow artery, but the flow is diminished or the direction reversed when the fistulous opening exceeds the diameter of the inflow artery by more than threefold.
- Chronic Changes: In a chronic AVF, the proximal artery enlarges and becomes elongated and tortuous. Degenerative changes characterized by atrophy of the elastic lamellae and smooth muscle cell layers and deposition of lipid and calcium result in features resembling atherosclerosis.

- Cardiac Effects: In patients with large AVFs, the increase in venous return results in cardiomegaly, which may develop acutely within weeks or months of the injury or may progressively increase in severity over a period of years.
- The ability of the myocardium to compensate for the ever-increasing preload is more likely in young, otherwise healthy individuals. Ultimately, if left untreated, cardiac decompensation ensues, and the patient manifests the symptoms and signs of high-output congestive heart failure (CHF).
- The increase in cardiac size is accompanied by a corresponding increase in the diameter of the aorta and vena cava proximal to the fistula; the dimensions of the vessels distally remain unchanged.

CLINICAL PRESENTATION:

- Most AVFs encountered by vascular surgeons are of the chronic variety; exceptions are traumatic AVFs and spontaneous AVFs that develop as a result of ruptured aneurysms.
- It is estimated that 49% to 66% of trauma patients with AVFs present acutely and require immediate repair. In the remaining patients, the diagnosis is missed initially and the presentation is delayed days, weeks, or years after the initial injury.

- History: The most common presenting symptoms of an AVF are a thrill or bruit (61%-74% of cases) or a pulsatile mass (20%32% of cases).
- Large fistulas may cause symptoms by diverting arterial blood away from the distal vascular bed. Consequently, patients may experience symptoms of arterial insufficiency that mimic those caused by arterial stenosis.
- Regional and local symptoms of venous hypertension may also be present in patients with large AVFs. An antecedent history of penetrating or iatrogenic trauma (renal or hepatic biopsy, central venous catheter placement, previous cardiac or vascular intervention), lumbar disk surgery, or preexisting AAA should be elicited.

- Symptoms of CHF, gastrointestinal bleeding, hematuria, and massive leg swelling, characteristic of large aortocaval, ilioiliac, arterioportal, or renal fistulae, should be ascertained.
- Physical Examination: Local manifestations can include both venous and arterial signs.
- Venous findings range from limb swelling with dilated veins to varicose veins, pigmentation, and ulceration in more chronic cases.
- Ipsilateral limb ischemia of varying severity is rare but can occur with both central and peripheral AVFs. Whether symptoms of leg ischemia develop depends on the size of AVFs, as well as embolization to the runoff vessels.
- All peripheral pulses should be evaluated. The only findings in patients with small fistulae may be a bruit or thrill beneath a scar or over a pulsatile mass.
- A careful search should be made for scars and incisions from previous trauma or operations.

- In patients with extremity AVFs, temporary compression of the artery proximal to the fistula elicits the Nicoladoni or Branham sign, consisting of slowing of the heart rate and a reduction in pulse pressure.
- An abnormal aortic pulsation and an epigastric bruit or thrill are suggestive of an intraabdominal AVF. Auscultation over the aorta, kidneys, liver, and spleen for the presence of a holosystolic murmur should be performed routinely.
- The symptoms and signs of CHF, elevated jugular venous pressure, tachycardia, low diastolic blood pressure, pulmonary rales, cardiomegaly with an S3 cardiac gallop rhythm, hepatomegaly, and peripheral edema—are present in up to a third of individuals with acquired AVFs.
- Specific Locations: Neck and Upper Extremity: A rapidly expanding hematoma, carotid bruit or thrill, and dilated neck veins suggest the diagnosis of a carotid-jugular AVF.
- Ischemic neurologic symptoms directly attributable to the carotid AVF may result from embolization or shunting of blood through the fistula.

- The clinical diagnosis of vertebral AVFs is often unsuspected; only half of patients present with overt signs and symptoms of vertebral artery injury, and ischemic neurologic symptoms are rare.
- Subclavian, axillary, and brachial AVFs may manifest with diminished or absent peripheral pulses, abnormal forearm blood pressure measurements, arm swelling, dilated veins, hand ischemic symptoms, and a pulsatile mass with a thrill and bruit.
- Radial and ulnar AVFs are usually asymptomatic and manifest as a thrill or bruit over a small pulsatile mass. Aortoiliac Abdominal or back pain is the presenting symptom in 70% to 80% of patients with spontaneous AVFs involving the aorta and iliac arteries.
- Most iatrogenic AVFs are small and will seal spontaneously. Certain risk factors, such as large communications, connections at branch points, and anticoagulation, may prevent closure of these procedure-related AVFs.
- Longstanding AVFs can lead to lower extremity arterial insufficiency due to a “steal” phenomenon.

DIAGNOSTIC IMAGING:

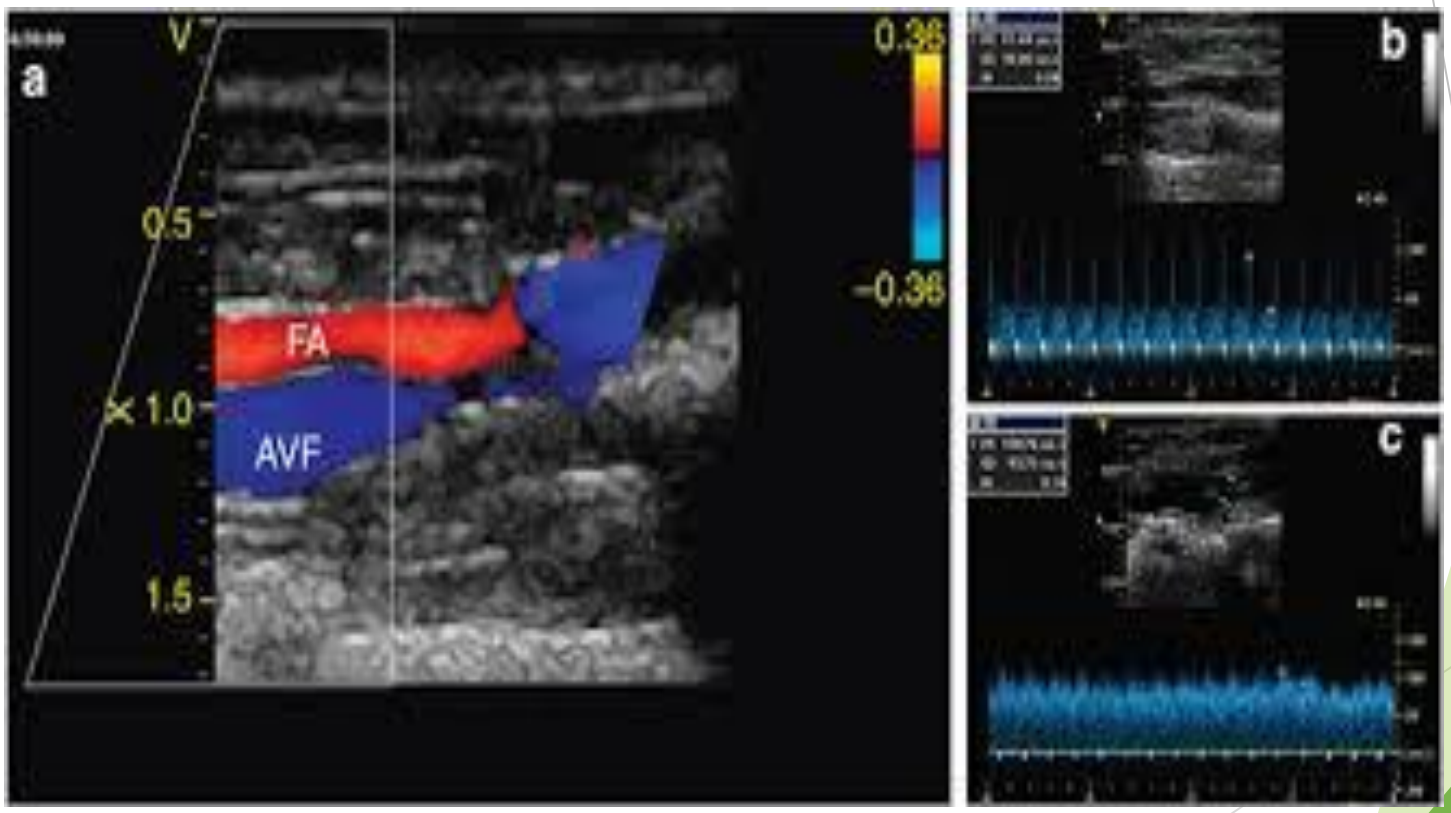
Plain chest and abdominal radiographs should be obtained in all patients with suspected AVFs to look for evidence of CHF and prior trauma, such as shotgun pellets or bullet fragments.

Rarely, calcification of a traumatic AVF may be present. Ankle-brachial indices are determined and venous and carotid duplex imaging is performed as indicated by the patient's symptoms.

Cardiac evaluation should include an electrocardiogram and echocardiography. Cardiac catheterization is not routinely necessary and is reserved for cases of diagnostic uncertainty.

The typical cardiac catheterization findings in patients with well-established AVFs include an increased cardiac output and elevated right atrial, right ventricular, and pulmonary artery wedge pressures, with a corresponding decrease in peripheral vascular resistance.

- Color-Flow Duplex Imaging Duplex findings: characteristic of AVFs include visualization of the fistulous connection, a color mosaic at the level of the fistula, and the presence of color pixels in the soft tissues adjacent to the fistula.
- Loss of triphasic waveforms in the artery proximal to the fistula, decreased flow in the distal artery, and continuous high-velocity flow in the vein cephalad to the fistula are the usual pulse Doppler findings.
- Although such imaging is useful in detecting AVFs and other arterial injuries, its sensitivity for detecting correctable defects such as intimal flaps is low compared with that of computed tomographic angiography (CTA) or angiography.
- The accuracy of the study is also highly dependent on technician skill, and in the acute setting, open and bleeding wounds, subcutaneous air, hematoma, and fractures limit its application.
- Patient body mass index and interference from anatomic structures also make visualization difficult in certain locations.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- Duplex imaging is an appropriate first choice for the diagnosis of an acquired AVF in a location such as the groin, where it has already been demonstrated to have high sensitivity and specificity for the diagnosis of arterial and venous pathology in general.
- Computed Tomography: CT scanning with or without contrast enhancement allows the rapid acquisition of images and is routinely used in the evaluation of trauma victims.
- CTA is an appropriate diagnostic tool in evaluating patients with suspected AVFs because it is minimally invasive, rapid, accurate, operator independent, and less expensive than conventional angiography.
- Magnetic Resonance Imaging: The utility of magnetic resonance angiography (MRA) in the evaluation of acute vascular injuries and acquired AVFs is limited by the inability of severely injured trauma patients to be monitored and ventilated in the scanner, longer image acquisition times, and patient intolerance of being in the scanner.

- In contrast, MRI and MRA are used extensively in the management of patients with vascular malformation including AVFs.
- These imaging methods facilitate diagnosis and treatment planning by delineating the underlying defect, measuring flow disturbances, and defining the relationship between the fistula and adjacent soft tissue structures.
- Conventional Angiography: Until recently, digital subtraction angiography was the diagnostic method of choice for determining the presence and location of arterial injuries as well as acquired AVFs.
- The typical angiographic features of an AVF are early venous filling and failure to opacify the distal vessels. However, it may be difficult to accurately locate the site of the fistulous communication by angiography alone, especially in AVFs with very high flow rates.
- In this situation, simultaneous selective catheterization of both the affected artery and vein is helpful in locating the site of the fistulous opening.

In very high flow AVFs, balloon occlusion of the inflow artery with contrast injection beyond the balloon can be helpful. A high-quality angiogram to identify the precise location of AVFs is essential for endovascular treatment.

Despite an associated morbidity of 0.6% to 2%, the benefits of its diagnostic accuracy and the potential for early percutaneous intervention outweigh the disadvantages of cost, availability, and risk of contrast-associated renal failure in the majority of patients.

Digital subtraction angiography with carbon dioxide is an excellent alternative to conventional angiography in patients with a history of contrast reaction or chronic renal failure.

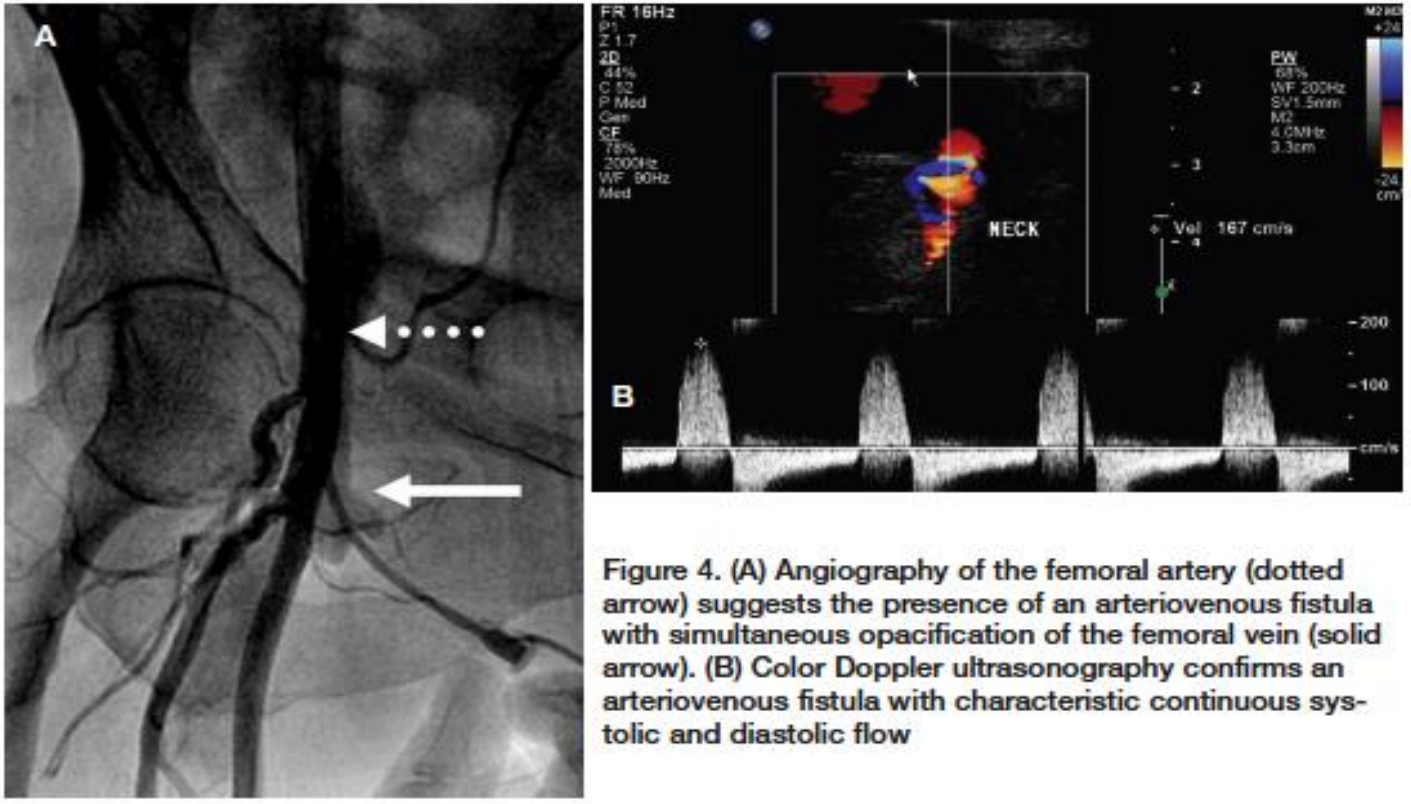


Figure 4. (A) Angiography of the femoral artery (dotted arrow) suggests the presence of an arteriovenous fistula with simultaneous opacification of the femoral vein (solid arrow). (B) Color Doppler ultrasonography confirms an arteriovenous fistula with characteristic continuous systolic and diastolic flow

PRINCIPLES OF MANAGEMENT:

- The management of AVFs consisted of watchful waiting until 1843, when Norris reported the successful treatment of a patient with an AVF by ligating the artery above and below the fistula.
- Soubbotitich, who treated 77 false aneurysms during the Serbian wars, subsequently demonstrated the success of primary arterial and venous repair.
- The essentials of AVF repair, as first proposed by Lexer, consisted of closure of the fistula, excision of the aneurysmal sac if present, and restoration of arterial flow with an interposition vein graft if an end-to-end anastomosis was not feasible.
- Lexer further concluded that repair of the vein was desirable but not mandatory. Despite these early reports of successful arterial repair, until recently, the most common therapy remained **quadruple ligation** and excision of any aneurysmal sac with a not unexpectedly high amputation rate of 49%.

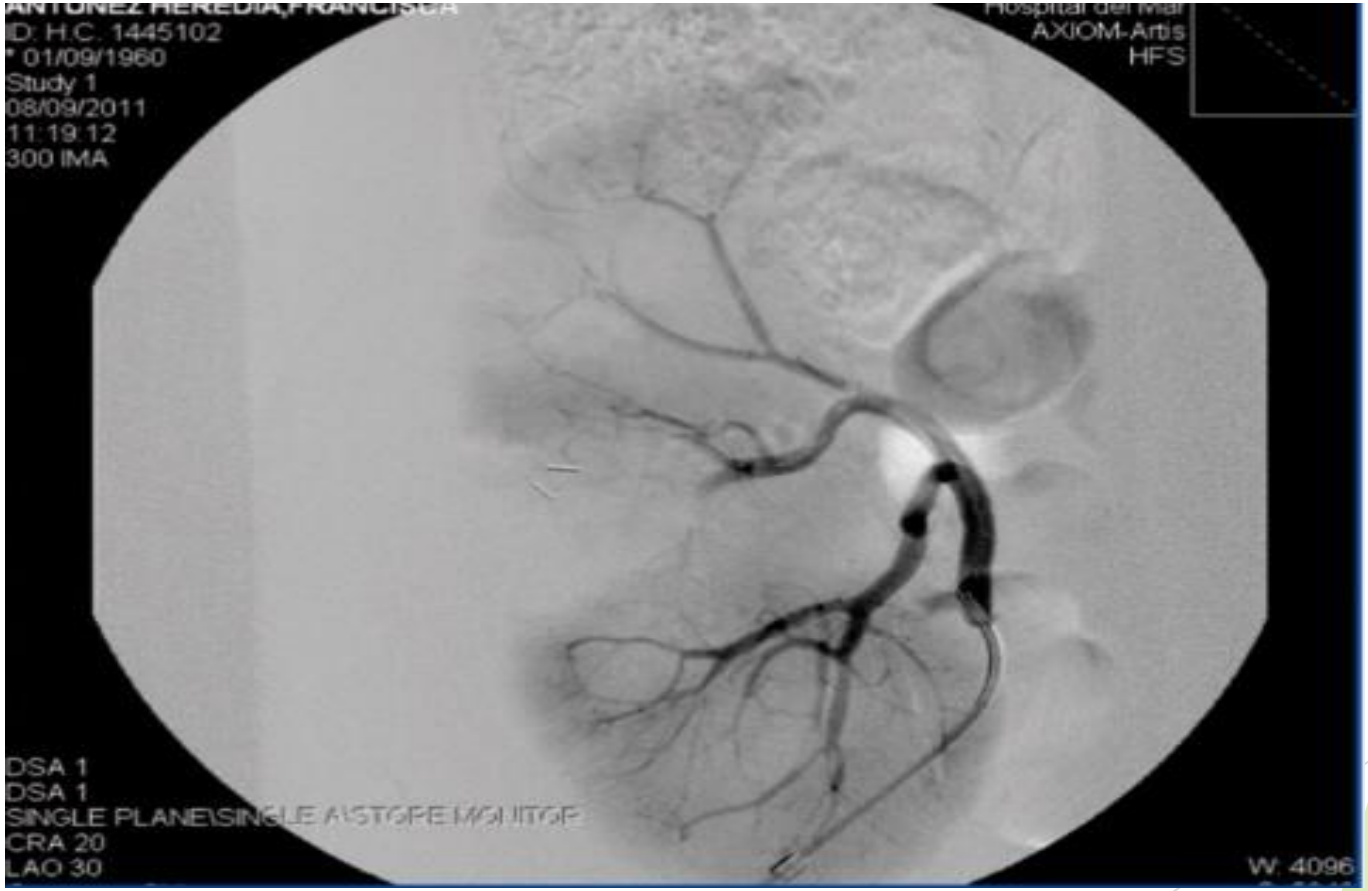
- The goals of current therapy for acquired AVFs are **closure of the fistulous opening**, restoration of normal hemodynamics, and reestablishment or maintenance of vascular continuity.
- A careful preoperative evaluation of cardiac risk and accurate localization of the AVFs are essential before undertaking surgical or endovascular interventions, although 20% to 38% are not diagnosed preoperatively.
- Surgery is indicated in good-risk patients with symptomatic AVFs and in those individuals whose anatomy is not suitable for endovascular repair or those for whom endovascular treatment has failed.
- Conservative Treatment: A large number of iatrogenic AVFs close spontaneously. Similar to renal AVF, Kelm et al observed that one third of iatrogenic groin AVF closed spontaneously within 1 year following cardiac catheterization, advocating conservative management for at least 1 year.

- Duplex Ultrasound-Guided Compression Therapy: The use of color-flow duplex ultrasonography to delineate the size and location of iatrogenic arterial defects and the successful management of postcatheterization pseudoaneurysms with ultrasound-guided compression have prompted some authors to advocate a trial of this therapy for superficial AVFs.
- Ultrasound-guided compression of AVFs has been used in a small number of cases in which a long communication tract existed between the artery and vein, with success rates of 0% to 30%.
- Successful occlusion of an AVF is unlikely if the artery and vein are closely adherent, if the defect is large or located at an arterial bifurcation, or if the communication is deep and not amenable to superficial compression.

- Endovascular Treatment: For many years, the only treatment option for repairing AVFs when conservative therapy failed was surgical closure of the defect. However, the morbidity associated with operative repair of AVFs and continuous advances in endovascular techniques and device design have increased the use of endovascular treatment for AVFs.
- In fact, endovascular therapy has become the treatment of choice for stable patients with suitable anatomy, poor-risk surgical candidates, and those with surgically inaccessible lesions of the neck, thorax, abdomen, and extremities.
- Endovascular treatment of AVFs may be accomplished by transcatheter embolization, placement of a stent-graft, or a combination of these two therapeutic modalities. Endovascular balloon occlusion can also help to assist surgical repair to minimize bleeding.

- Prerequisites for the endovascular treatment of an AVF in any location are that the artery involved is accessible above and below the lesion and that the patient has the appropriate anatomy to allow deployment of the embolic material or stent-graft.
- Only a few series of patients with AVFs undergoing endovascular therapy have been reported; however, the initial results are promising, and the complication rate is relatively low.
- Endovascular Techniques: Embolization: Transcatheter embolization is used to treat acquired cervical, visceral, and extremity AVFs.
- The embolic agents available include autologous clot, gelatin sponges, microfibrillar collagen, polyvinyl alcohol particles, metal coils, detachable balloons, and liquid embolic agents such as N-butyl cyanoacrylate (n-BCA).
- The choice of embolic agent depends on a number of considerations: the size of the vessel to be embolized, the caliber of the delivery catheter required to reach the target, and whether repeated embolization is anticipated.

- Successful embolization of AVFs requires accurate positioning of the catheter at the site of the AVF before delivering the balloon, embolic liquid, or coil to occlude the fistula.
- Microcoils and particulate and liquid agents deployed through coaxial microcatheters are generally used for small branch cervical, renal, visceral, or extremity AVFs, with high technical success rates reported.
- Although a limited number of reports have been published on the embolization of visceral AVFs, principles similar to those used for the endovascular treatment of large visceral aneurysms can be applied.
- Gabelmann et al reported a 92% initial success rate treating visceral aneurysms with coil embolization, with a 4% mortality rate and a single recurrence at 1 year.
- Multiple interventions are usually necessary to achieve this level of success for AVF, but coiling of acquired splenic, hepatic, mesenteric, and renal AVFs is generally effective and can preserve flow in the parent vessel.
- The major risk associated with transcatheter embolization of AVFs is embolization to the lung and arteries related to the fistula, resulting in parenchymal or extremity ischemia.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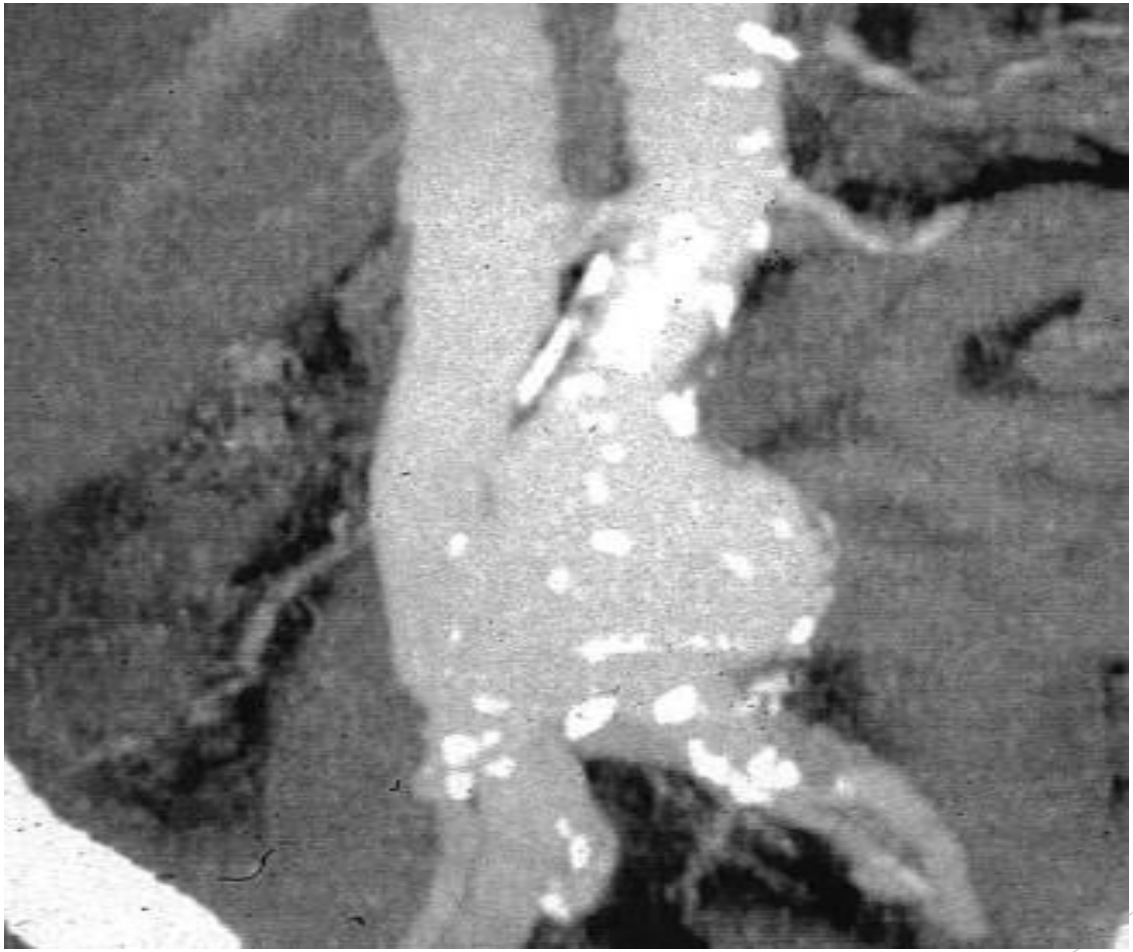
Stent Graft

- Although the use of covered stent-grafts to treat AVFs in the lower extremity is technically feasible, a number of concerns exist regarding their placement in these locations. Kinking and bending are major concerns when they are placed in the groin and across the knee joint.
- Additionally, because the common femoral artery is the access site for 85% to 90% of angiographic interventions, placement of a covered stent in that artery may preclude its use for access should additional procedures become necessary. Placement of covered stents in the profunda femoris artery may occlude some of its branches.
- Finally, obtaining a covered stent of adequate size remains a problem with AVFs of the tibial and peroneal arteries. Covered stents have also been used to treat supraaortic trunk AVFs.



- Surgical Treatment: Urgent operative repair is indicated in patients with acute AVFs if there is active bleeding, cardiac decompensation, pulse deficit, evidence of acute visceral or extremity ischemia, or other injuries requiring operation. Surgical repair is recommended for young, healthy patients and for those with chronic AVFs whose lesions or anatomy are unsuitable for endovascular repair.
- Aortocaval Fistulae In patients undergoing operative treatment for AVFs, the surgical field is prepared to permit proximal control of the aorta in the upper abdomen or chest. A thoracoabdominal incision is the safest approach if a supraceliac AVF is encountered.
- With spontaneous AVFs, the AAA and enlarged IVC are usually evident, whereas in patients with traumatic or iatrogenic aortocaval fistulae, palpation of a thrill and a mildly enlarged aorta and IVC are indicative of an AVF.

TREATMENT OUTCOMES:

- Surgical and endovascular repair of a large AVF can lead to dramatic hemodynamic changes. Immediate rise in systemic vascular resistance, decrease in central venous pressure, increase in regurgitant flow across the aortic valve, and decrease in central mixed venous oxygenation may be observed.
- A combination of vasodilators and vasopressors is often needed to maintain hemodynamic stability and a reasonable cardiac output. Precautions should also be taken to avoid the known complication of air embolization during surgical treatment.
- Surgical Treatment: The outcome of treatment of AVFs involving the abdominal aorta and iliac arteries depends on the patient's age, the cause of the fistula, and the duration and severity of hemodynamic alterations. Patients with spontaneous AVFs are older and have more comorbidities than do typically younger individuals with traumatic AVFs.
- Intraoperative blood loss, pulmonary embolism, myocardial infarction, stroke, and multisystem organ failure account for a morbidity rate of 39% and a mortality rate of 34% following surgical repair of spontaneous AVFs.

- Long-term graft patency is an excellent 96% in surviving patients. Because patients with traumatic aortocaval or ilioiliac AVFs are younger, lower perioperative mortality and better long-term outcomes are anticipated.
- Surgical repair of postcatheterization AVFs is successful and, until recently, was the treatment of choice for these lesions. However, the need to operate emergently on often unstable patients with prolonged bleeding and clotting times may be associated with significant systemic and groin wound morbidity, enhancing the appeal of endovascular treatment of these lesions.
- No reports specifically address the treatment outcomes of visceral AVFs. However, the surgical mortality rate for the elective treatment of visceral artery aneurysms is about 5%; this increases to 10% to 25% in patients with ruptured splenic artery aneurysms and to 21% in those with ruptured hepatic aneurysms. Similarly, limited information is available on the outcome of renal AVFs repaired surgically.

- Vascular closure devices are now frequently used after percutaneous catheterization and intervention in the groin. Although the use of these devices is associated with a reduction in the time required to achieve hemostasis and ambulation, whether they can reduce the number of AVFs, hematomas, and pseudoaneurysms remains controversial.
- No report specifically addresses the outcome of treating visceral AVFs. In a recent series of 90 patients with visceral artery aneurysms or pseudoaneurysms reported by Tulsyan et al, 53% were managed with endovascular treatment.
- Coil embolization was successful in 98% of patients, with a perioperative mortality rate of 8.3%. The authors also reported 0% mortality but a 40% infarction rate in patients with splenic artery aneurysms.
- The mortality rate was 11% following embolization of hepatic aneurysms without significant hepatic ischemia. Only 23% to 36% of renal AVFs require treatment, and transcatheter embolization or placement of a stent-graft in such lesions is associated with a 90% success rate.

SELECTED KEY REFERENCES:

- Cinara IS, Davidovic LB, Kostic DM, Cvetkovic SD, Jakovljevic NS, Koncar IB: Aorto-caval fistulas: a review of eighteen years of experience. Acta Chir Belg 105:616–620, 2005.
- Good overview of the clinical presentation, management, and long-term outcome of the treatment of AVFs in one of the largest series reported. du Toit DF, Lambrechts AV, Stark H, Warren BL: Long-term results of stent graft treatments of subclavian artery injuries: management of choice for stable patients. J Vasc Surg 47:739–743, 2008.
- Largest series in the literature of the endovascular treatment of subclavian artery injury with 48-month follow-up. Kelm M, Perings SM, Jax T, Lauer T, Schoebel FC, Heintzen MP, Perings C, Strauer BE: Incidence and clinical outcome of iatrogenic femoral arteriovenous fistulas. J Am Coll Cardiol 40:291–297, 2002.
- Prospective study reporting on the incidence and clinical outcome of femoral AVFs in a cohort of more than 10,000 post–cardiac catheterization patients followed for 3 years. Miller-Thomas MM, West OC, Cohen AM: Diagnosing traumatic arterial injury in the extremities with CT angiography: pearls and pitfalls. Radiographics 25:S133–S142, 2005.
- Good overview of the indications for, as well as the technique and pitfalls of, using CTA in extremity trauma. Papadoulas S, Konstantinou D, Kourea HP, Kritikos N, Haftouras H, Tsolakis JA: Vascular injury complicating lumbar disc surgery: a systematic review. Eur J Vasc Endovasc Surg 24:189–195, 2002.

THANK YOU