# 12 Dialysis Fistulae and Grafts

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## Pathophysiology

End-stage renal disease (ESRD) affects 660,000 patients in the United States and over two million people globally. Of the ESRD patients in the United States, 468,000 are dialysis patients. Furthermore, the dialysis population is growing 4–6% annually, with prevalence increasing at a higher rate because people are living longer. An effective hemodialysis treatment is dependent on a well-functioning vascular access which has good blood flow, has long-term patency, and allows two to five times per week dialysis treatment over the patient's lifetime. There are three types of vascular access: arteriovenous fistula, arteriovenous graft, and venous catheter. The venous hemodialysis (HD) catheter is described in Chap. 9.

## Arteriovenous Fistula

An autogenous arteriovenous fistula (AVF) is preferred for long-term access for dialysis due to its lowest rates of infection and thrombosis, best potential blood flow, and least expense. In 1966, Brescia, Cimino, Appel, and Hurwich described the surgical creation of the arteriovenous fistula which is a connection between a native artery and vein, typically in the arm [1, 2]. In 2003, the "Fistula First" initiative, a continuous quality improvement project, aimed to increase the use of fistulae for hemodialysis access. In 2009, the goal was set to 65% prevalence which was largely reached.

The most common types of fistulae are the radiocephalic fistula in the forearm, the brachiocephalic fistula in the upper arm, and the transposed brachiobasilic fistula where the basilic vein may be surgically elevated to make it more accessible. Less common types are the ulnar-basilic forearm fistula, the percutaneous ulnar-ulnar fistula, and a variety of obscure leg fistulas [3].

After surgery, the outflow vein needs to gradually enlarge to allow repeated punctures, a process called maturation. Maturation time can be long, subjecting patients to prolonged catheter dependency and their associated morbidity and mortality due to higher rates of venous thrombosis and bloodstream infections [4]. Up to 60% [5] of fistulae may fail to mature enough to support dialysis. The rule of 6's from Kidney Dialysis Outcomes Quality Initiative (KDOQI) is the most commonly used consensus definition to describe fistula maturation although several other anecdotal definitions have been proposed. KDOQI is described in detail later [6]. The fistula vein should be 6 mm in diameter and less than 6 mm below the skin and have at least 600 ml/min flow. This definition is a consensus definition not based on any objective data. Another sonographic criteria of maturation is a vein diameter of ≥4 mm, and brachial artery flow is >500 ml/min [7]. Ultimately, the real determinant of fistula maturation is whether it supports therapeutic two-needle dialysis.

> **Key Point**
> KDOQI rule of 6's
>
> - Fistula vein >6 mm
> - <6 mm below the skin
> - At least 600 mL/min flow rate

Aneurysmal fistula veins are common, and unlike graft pseudoaneurysms, these are not pathologic sites of contained rupture. They are most frequently found in areas of needling and are often the result of a downstream stenosis increasing intra-fistula pressure [8]. However, they can be potential areas of life-threatening rupture if the overlying skin over them is

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taut, is shiny, or has an overlying scab. In these cases, urgent surgical consultation is recommended for possible revision.

Occasionally the entire fistula becomes enlarged which is also known as a "mega fistula." When such a fistula becomes clotted, it can contain >20 ml of clot. Such fistulas are very difficult to declot and carry a high risk of clinically significant periprocedural pulmonary emboli. Surgical thrombectomy can be considered. There has been limited success with overnight catheter-directed thrombolytic therapy for such cases.

## Arteriovenous Graft

The arteriovenous graft consists of a piece of prosthetic tubing interposed between an artery and a vein where the tube itself is punctured during dialysis. Dialysis grafts are composed of a variety of different materials: the most common is polytetrafluorethylene with a diameter of 6 mm or tapering from 4 to 7 mm. Since a prosthetic material is used to bridge the artery and vein, infection is more common than with a native fistula. Dialysis grafts can be placed within the leg, chest, and most commonly within the arms in a straight or looped configuration. Within the leg, the graft spans the femoral artery and the femoral or saphenous veins. The rare necklace graft is created between the subclavian artery on one side and the subclavian vein on the other side of the chest.

Forearm grafts are most commonly looped between the brachial artery and cephalic/basilic vein with the anastomoses near the elbow. A straight configuration can also be placed between the radial artery in the distal forearm and the cephalic/antecubital or basilic vein near the elbow. Within the upper arm, the most common configuration is the straight graft between the brachial artery and basilic or axillary vein.

## Physical Examination of the Patient

The physical exam has been proven to be as accurate at diagnosing the cause of access dysfunction as the measures of adequacy obtained during dialysis such as recirculation, kt/v, and flow rates. Examining the arms can help determine areas of prior and current access. Furthermore, it can demonstrate if central venous stenosis or occlusions exist – if the arm with the dialysis access is swollen relative to the non-access arm, a central venous lesion is likely (Fig. 12.1). It is very important to differentiate a dialysis fistula from a dialysis graft as location of stenosis, direction of access for intervention, and outcomes are different. Dialysis grafts are palpable as rigid tubular structures then compress but with some difficulty. Noting their location and configuration helps with planning intervention. Dialysis (autogenous) fistulas are also tubular but more compressible and "rubbery" to the touch; this represents dilated veins that have been arterialized by surgically anastomosing them to arteries within the arm.

**Fig. 12.1** Patient with a right arm brachiocephalic fistula. Note the swollen right hand and distal forearm relative to the left suggesting central venous stenosis or obstruction on the right

Most importantly, note the presence or absence of a palpable thrill or audible bruit. A bruit sounds like a continuous whooshing noise, and a thrill feels like a constant vibration which corresponds to the blood passing through the fistula. These are in contrast to a prominent pulse which would suggest a patent access with a nearby downstream stenosis. If a thrill or pulse is absent, the dialysis access is likely thrombosed or has a severe inflow (arterial) or outflow (venous) stenosis. If a thrill is present, a change in the nature and extent of the thrill throughout the access can localize an area of stenosis. Thrombosis, stenosis, and infection are the three most prevalent complications.

Steal syndrome is a clinical diagnosis representing insufficient arterial perfusion to the distal arm/hand. The dialysis access "steals" too much blood from the brachial artery rendering the hand ischemic. Physical examination will reveal a mottled hand, loss of pulses, poor finger oximetry waveforms, and potential sensory disturbance. Urgent surgical consultation is recommended which may consist of banding the fistula to reduce its caliber, a DRIL procedure to reroute flow, or in rare cases intentionally shutting down the access. The later can be performed endovascularly.

**Key Point**

How to differentiate AVF from AVG

- AVF are easily compressible and rubbery to the touch.
- AVG have a rigid tube which is compressible but with difficulty.

**Fig. 12.2** Thrombosed loop thigh graft. After insertion of the sheath, pus was aspirated. Note the air within the graft consistent with gross infection (black arrows)

**Fig. 12.3** Patient from Fig. 12.1 with a right brachiocephalic fistula. In addition to a swollen arm, a dilated venous chest wall collateral is visible also strongly indicating central venous stenosis or obstruction

> **Key Point**
> On physical exam, a bruit is heard, while a thrill is palpated.

Other key findings on examination include erythema, warmth, and tenderness which may reflect cellulitis and infection (Fig. 12.2). Finally, for dialysis fistulae, some patients use an access technique called a "button hole" wherein they insert their dialysis needles at the same locations every time. These hardened areas may provide easier access but can become focal areas of eventual stenosis. Dilated chest wall veins may suggest central venous stenosis or occlusion (Fig. 12.3). Multiple scars from previous dialysis catheters suggest a greater risk of central venous disease. Both dialysis catheters and grafts are associated with higher risk of infection and a greater number of interventions than AV fistula to maintain patency. Graft infection is relative contraindication to angioplasty and an absolute contraindication to declotting. Septic embolization of infected thrombus is the primary concern and carries a high risk of mortality. When accessing the graft, aspiration with the puncture needle may return pus.

Over the past two decades, interventional radiologists have increasingly become involved in the evaluation and treatment of hemodialysis access. The concerted effort between interventional radiologists, vascular surgeons, and nephrologists has proven effective in prolonging vascular access patency and decreasing morbidity and mortality of ESRD patients.

> **Key Point**
> Easiest way to differentiate arterial from venous limb of a graft? Ask the patient.

> **Key Point**
> Easiest way to determine the direction of flow within the graft is to compress in the middle and feel which side has a pulse.

## Clinical Indication

The indication for intervention in an access is clinical dysfunction combined with angiographic and/or ultrasound evidence of a significant vascular stenosis. Clinical indications include but are not limited to high pressures during dialysis, poor measured flow rates with ultrasound or Transonic measurement (dilution flow measurements at the time of dialysis), swollen arm or neck and face, prolonged bleeding time after needle removal, painful dialysis, hand or digital ischemia due to potential steal, frequent clotting of dialysis lines, and inadequate dialysis. Angiographic/ultrasound criteria is >50% luminal narrowing.

Ultrasound can be used to diagnosis sites of stenosis and thrombosis and equally guide needle access into the graft or fistula. However, ultrasound is not suitable for assessing the central veins. The primary imaging modality for evaluating the entirety of the access circuit, from artery to atrium, is catheter angiography. While CT and MRI have been described, both these modalities are costly and time-consuming and do not allow intervention.

Approach for fistulography in fistulas is more variable than in grafts given the variability of location of lesions in different types of fistulas. Physical examination and sonography help determine where stenoses and guide access points for catheter insertion. Generally, for radiocephalic fistulas, the fistula should be punctured toward the arteriovenous anastomosis. For brachiocephalic fistulas, if the fistula is pulseless, puncture toward the anastomosis; if it is pulsatile, puncture toward the outflow. For brachiobasilic fistulas, puncture toward the outflow. A unique approach for imaging and intervention is via the radial artery which provides access to the inflow artery and venous outflow of fistulas [9].

For fistulography of grafts, access is obtained near the arterial anastomosis since most stenoses occur downstream within the graft, at the venous anastomosis, or in the arm or central veins. Nevertheless, the arterial anastomosis is always assessed. This can be done with sonography or by refluxing contrast backward via (1) manually compressing the venous limb of the graft while injecting, (2) inflating a blood pressure cuff to suprasystolic pressures central to the graft, or (3) injecting contrast through the sheath when the angioplasty balloon is inflated when treating a venous stenosis. An injection of 10 cc of iodinated contrast usually suffices. Diluting it 50% with normal saline may allow you to “see through” the contrast to discern areas of stenosis. It is important to obtain orthogonal views to assess severity of stenosis, see them in profile, and remove overlapping veins.

Kidney Dialysis Outcomes Quality Initiative (KDOQI) is a consensus guideline document which outlines treatments and outcomes for all of end-stage renal care. The last revision was published in 2006 with another revision currently in development with potential publication in 2018. It is important to know that multiple guidelines are based on retrospective data and, where little exists, based on consensus opinion. Key outcome guidelines:

- Primary patency rate of 50% at 6 months after percutaneous transluminal angioplasty (PTA).
- Surgical revision should be considered if more than two PTA events of the same lesion is performed within 3 months.
- Clinical success rate of 85% with a primary patency rate of 40% at 3 months for percutaneous declotting of dialysis access [6].

Recent prospective studies of angioplasty outcomes have shown lower patencies than these recommended goals [10–12].

There remains no clear consensus whether routine monitoring and interventions improves the overall patency and useable life of an access. However, there are studies that have shown a decreased rate of access thrombosis with imaging-driven interventions in patent but failing accesses [13]. Monitoring can be performed with duplex ultrasound or ultrasound dilution technique (e.g., Transonics).

## Conventional Therapy

Historically, conventional therapy included surgical patch angioplasty or jump grafts. These have largely been supplanted by endovascular interventions such as balloon angioplasty and use of stent grafts or stents.

## Interventional Therapy

### AVG Angioplasty

Stenosis is most commonly found at the venous anastomosis between the distal end of the dialysis graft and the outflow vein (~70%) (Fig. 12.4). The stenosis is caused by neointimal hyperplasia which is composed of collagen, fibroblasts, and smooth muscle cells. Over time, the stenosis progresses continually narrowing the outflow channel until stasis results in thrombosis. Stenosis can also occur anywhere within the access circuit from subclavian artery through the access and to the superior vena cava.

The most common treatment of stenosis is balloon angioplasty. An angioplasty is considered successful when there is <30% residual stenosis and the clinical indication for intervention has resolved. Ideally, the balloon diameter should be equal to or 10% larger than the non-stenosed vessel or graft located before or after the stenosis. The balloon length should sufficiently cover the length of the lesion plus 1 cm beyond the lesion to prevent “watermelon seeding” or slippage of the balloon during inflation. In most cases, operators

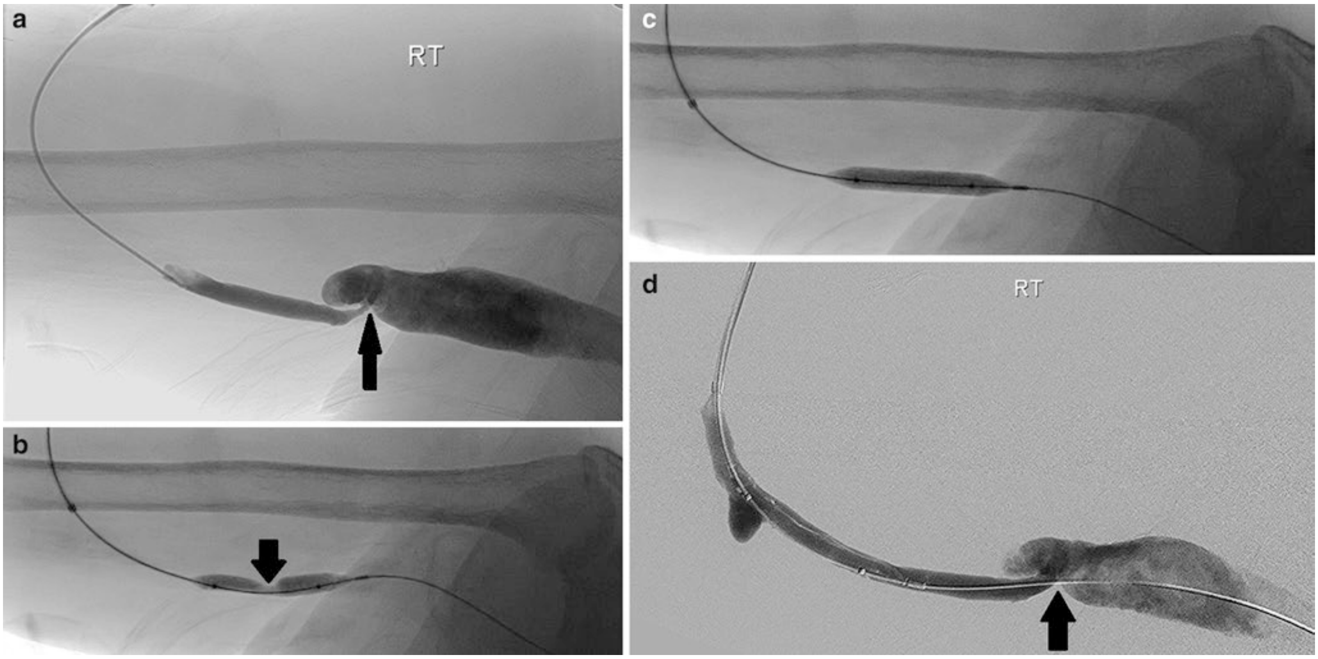


**Fig. 12.4** Patient with a brachiobasilic loop graft in the upper arm. (**a**) Initial fistulogram demonstrates greater than 75% stenosis at the venous anastomosis (arrow) where the graft is anastomosed with the basilic vein. (**b**) An 8 mm angioplasty balloon was used to dilate the stenosis which is visible as an indent in the balloon (arrow). (**c**) The balloon is completely effaced indicating full dilation of the stenotic vein segment. (**d**) Completion fistulogram demonstrates resolution of the stenosis (arrow)

visually estimate the lesion and choose their balloon size. Prolonged inflation time of more than 1 min is recommended, although evidence and support are limited. Recommended patency according to KDOQI after PTA is >50% after 6 months. However, multiple randomized studies indicate that graft patency is actually much lower and ranges from 23% to 40% at 6 months [10–12].

**Key Point**
Technically successful angioplasty is defined <30% residual stenosis angiographically.

**Key Point**
Indication for intervention is a clinical indicator of dysfunction AND a lesion that is angiographically >50% narrowed. The presence of stenosis alone in the absence of a clinical indicator is not an indication for intervention.

**Key Point**
Balloon size should be 10% larger than adjacent normal vessel or graft diameter and longer on both ends by 1 cm.

**The How to**
Prior to intervention you must understand the clinical indication for the patients' referral and planned intervention. Examine the access, and determine where the problem(s) is likely located. Consider sonography to validate your findings.

1. Puncture the access site upstream of the anticipated problem site(s). Following the Seldinger technique, advance a small catheter is placed into the fistula.
2. Perform contrast venography from the arterial anastomosis to the right atrium to evaluate the entire access circuit.
3. Declot if needed. This can be performed with a variety of devices using both mechanical and thrombolytic agents.
4. Balloon angioplasty +/– stent graft the identified area of stenosis.
5. Perform final fistulogram, and examine the fistula to assess thrill.
6. Obtain hemostasis. When holding pressure on the fistula, it is important to not occlude the vessel and cause thrombosis.

Often at sites of needle placement, the graft material deteriorates resulting in a hole or "rupture" of the graft

(continued)

which is contained by perigraft scar tissue which often bulges out. These pseudoaneurysms can be accompanied by breakdown of the overlying skin or large scab formation, which may signal a risk of impending and potentially life-threatening bleeding (Fig. 12.5). Consultation with an access surgeon is highly recommended to plan urgent surgical salvage. If surgery is not an option, pseudoaneurysm exclusion with a stent graft should be considered.

**Fig. 12.5** Forearm straight graft with an eschar over the site of repeated puncture. This is a site of impending graft rupture and possible life-threatening bleeding

## AVF Angioplasty

The locations of stenoses vary based on the type of fistula. Two-thirds of radiocephalic fistulae stenoses develop in the juxta-anastomotic zone, which is within 2 cm of the arterio-venous anastomosis. In contrast, brachiocephalic fistulae stenosis develops in 50% at the juxta-anastomotic zone (Fig. 12.6) and upper arm, while 30% develop stenoses in the cephalic arch (the terminal portion of the cephalic vein as it enters the axillary vein) and the remaining 20% develop narrowing in the central veins [14, 15]. Brachiobasilic fistulae most commonly narrow at the “swing point” of the basilic vein as it traverses from the superficialized portion to the deep natural location [16] (Fig. 12.7). As with grafts, angioplasty balloon diameter is determined from the size of the adjacent normal vein. As a rule of thumb, juxta-anastomotic fistulae are dilated to at least 6 mm and the remainder of stenoses to 8 mm. The procedure is similar to angioplasty for an AVG.

Patency following angioplasty is dependent on the type of fistula and location of stenosis. In forearm fistulas, 6-month primary patency ranges from 55% to 75%, and for brachiocephalic fistulas it ranges from 50% to 60% [14, 17, 18]. For cephalic arch stenosis, 6-month patency ranges from 0 to 40% [15, 19] (Fig. 12.8). Poorer patency is thought to relate to constraint of the vein as it passes through the delto-pectoral fascia and/or the angle of the vein as a point of shear stress from high blood flow as it passes from the arm into the axillary vein.

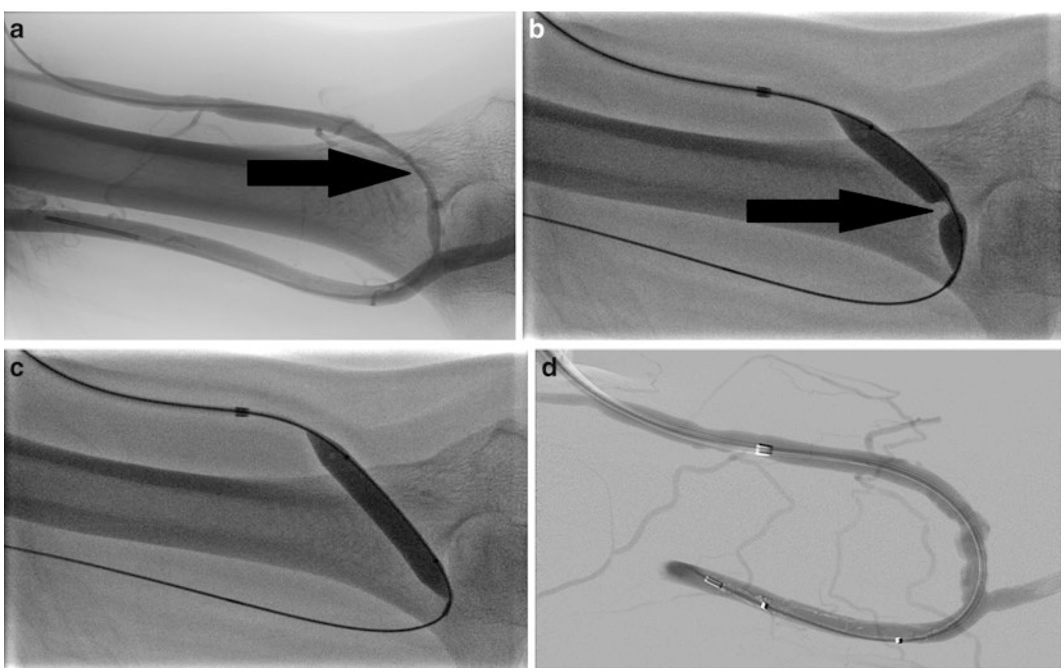


**Fig. 12.6** Patient with a left arm brachiocephalic fistula. (**a**) Stenosis is in the juxta-anastomotic portion of the fistula (arrow). (**b**) The stenosis is dilated with an 8 mm balloon with an indent in the balloon indicating the area of stenosis (arrow) – note that no portion of the balloon was advanced into the brachial artery. (**c**) The balloon is fully effaced indicating successful dilation of the stenosis. (**d**) Completion fistulogram shows no significant (>30%) residual stenosis

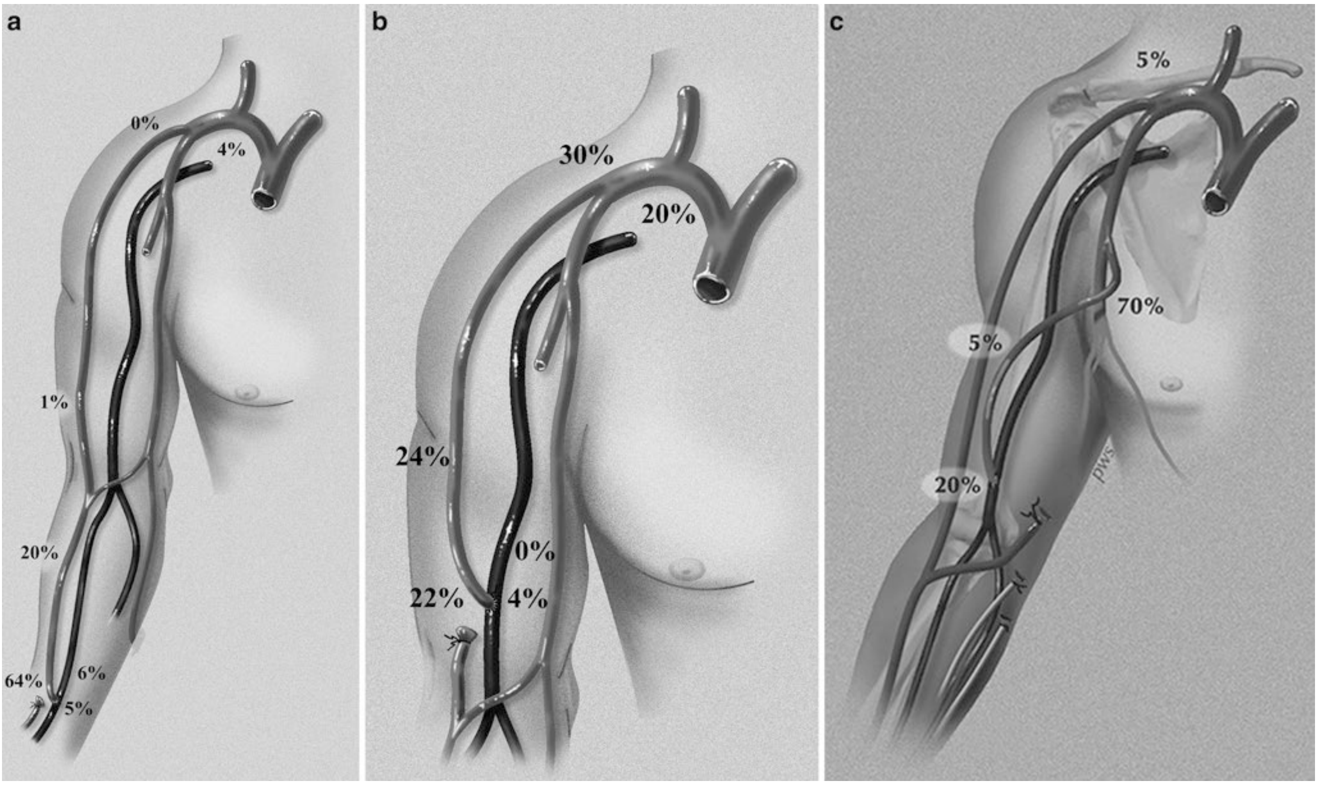


**Fig. 12.7** Location of stenosis within autogenous fistulas with incidence expressed as a percentage. (**a**) Radiocephalic fistulas. (**b**) Brachiocephalic fistulas. (**c**) Transposed brachiobasilic fistulas (Reprinted from Essentials of Percutaneous Dialysis Interventions, Interventions in Dialysis Fistulas, 2011, Dheeraj K. Rajan, Dirk S. Baumann. With permission of Springer)

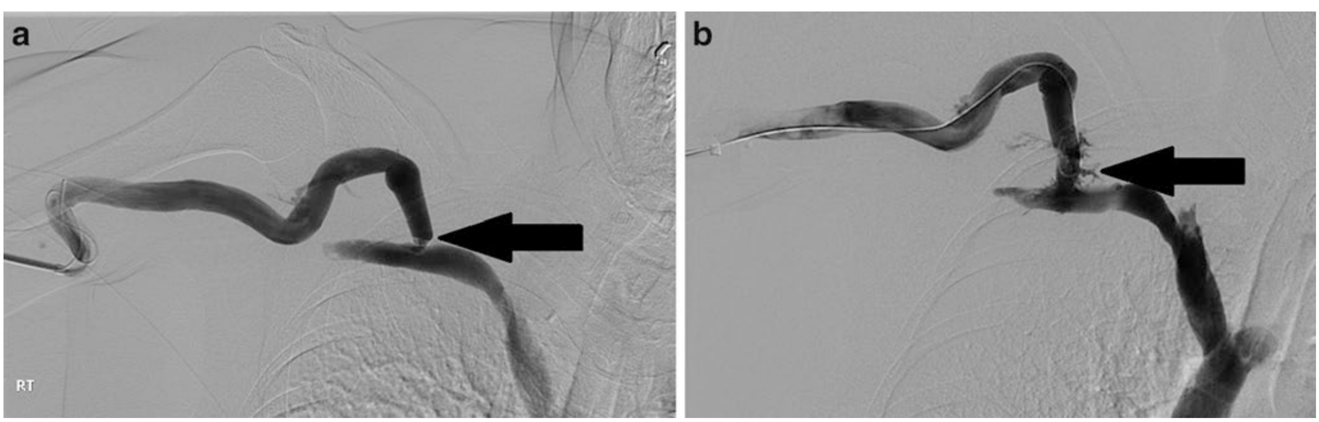


**Fig. 12.8** Patient with a right arm brachiocephalic fistula with high venous pressures during dialysis. (**a**) Fistulogram demonstrates focal stenosis of the cephalic arch at the point where the cephalic vein enters the axillary vein (arrow). (**b**) Following angioplasty, stenosis has been successfully treated (arrow). Minimal extravasation (contrast outside the vein) is seen in the area of dilation that did not require further intervention

## AVF Failure to Mature

The most common cause of failed AVF maturation is underlying downstream venous stenosis (Fig. 12.9). Intrinsic failure of the vein to dilate combined with competing flow through venous collaterals is less common. Stenosis most commonly occurs in the juxta-anastomotic vein, within 2 cm of the artery. The artery may also stenose which is an under recognized cause of failure of maturation. Finally, the entire length of the outflow vein(s) may be narrowed or occluded due to prior phlebotomy, venipuncture, or other intravenous catheters. For simple stenoses <4 cm in length, the angioplasty balloon size is determined by the size of the adjacent normal vessel diameter. When a long length of outflow vein is narrowed, a technique called balloon-assisted maturation (BAM) can be tried; this consists of sequential 2-week dilatations

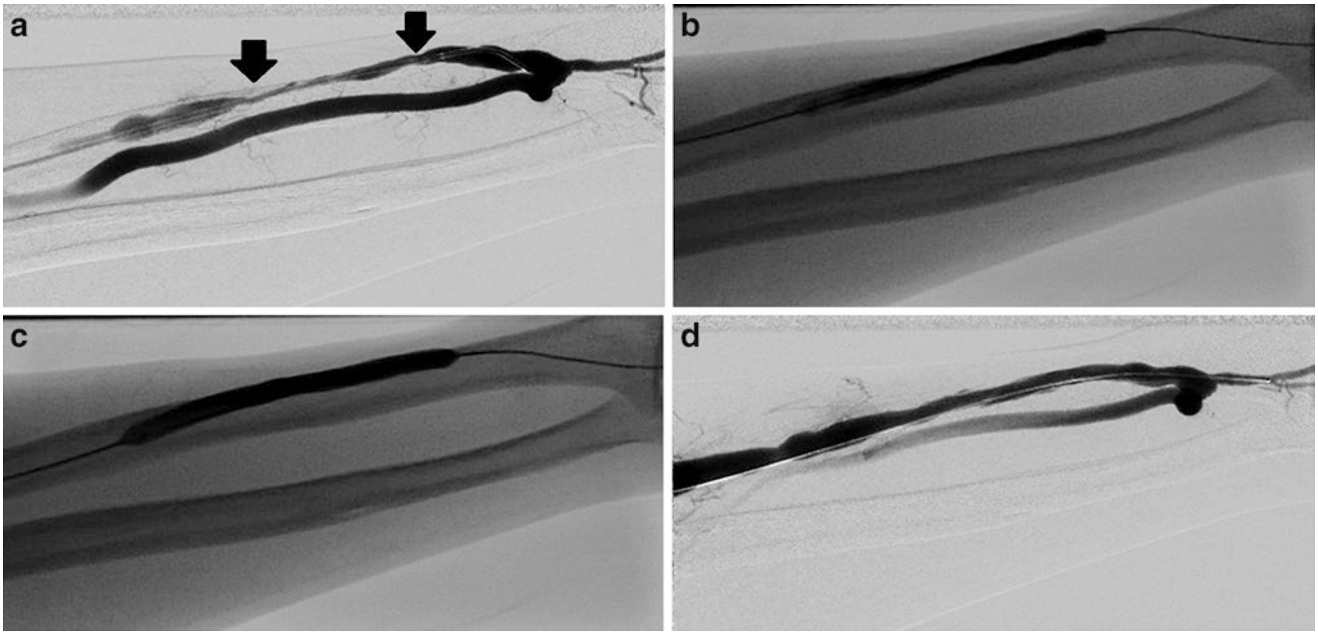


**Fig. 12.9** Patient with a radiocephalic fistula that is failing to mature. (**a**) Fistulogram demonstrates stenosis of the cephalic vein in the proximal fistula (between the arrows). (**b**) Stenosis is dilated with a 6 × 80 mm drug-eluting balloon with the hope of improved patency. (**c**) Area of stenosis is fully effaced by the balloon. (**d**) Completion fistulogram demonstrates no significant residual stenosis

using increasingly larger balloons, e.g., 4-, 6- and 8-mm diameter balloons. When doing so, most compress the arterial inflow to reduce the risk of extravasation through induced tears in the vein. Unfortunately the BAM procedure has limited success, with fistula patency rare at 2 years [20].

Coil embolization of venous collaterals has been suggested to help mature fistulae by directing all of the arterial inflow through a single-target fistula vein. This practice is controversial because the scientific evidence supporting this is weak. Further, following treatment of an underlying stenosis collateral veins typically disappear [21].

## AVG Thrombectomy and Declotting

> **Key Point**
> It is essential to remove all clots and treat all underlying significant stenosis. Quicker to declot after thrombosis = higher success rate.

The primary cause of dialysis access thrombosis is an underlying stenosis. Other causes include hypotension, excessive and prolonged access compression, and access site infection. Declotting success rates are better when performed sooner and in particular less than 1 week from the time of thrombosis. Target patency rates after declotting should exceed 40% at 3 months [6].

The key to successful declotting is treating all significant underlying stenoses, occasionally excepting central venous stenoses or occlusion while removing all possible clots.

The two methods are pharmacomechanical thrombolysis and purely mechanical thrombolysis. Systemic unfractionated heparin is typically administered to minimize re-thrombosis during the procedure; a general guideline is 80 units/kg. Often, two accesses are inserted with one in the venous limb pointing to the arterial anastomosis and one in the arterial limb pointed to the venous anastomosis to allow for removal of all clot; this is termed "crossing sheaths." There are a number of methods and devices used to declot an access, but the fundamentals remain the same. At the arterial anastomosis, a platelet-rich plug is usually present and does not lyse with thrombolytics. This plug is mechanically removed with an embolectomy balloon catheter or with a mechanical thrombectomy device.

> **Key Point**
> Prophylactic anticoagulation has shown no benefit in prevention of access thrombosis.

Pharmacomechanical thrombectomy utilizes a combination of thrombolytics with balloon maceration and aspiration of clot. The thrombolytic can be injected into the access earlier (lyse and wait technique) or at the time of intervention (lyse and go). The lytic will typically not entirely dissolve

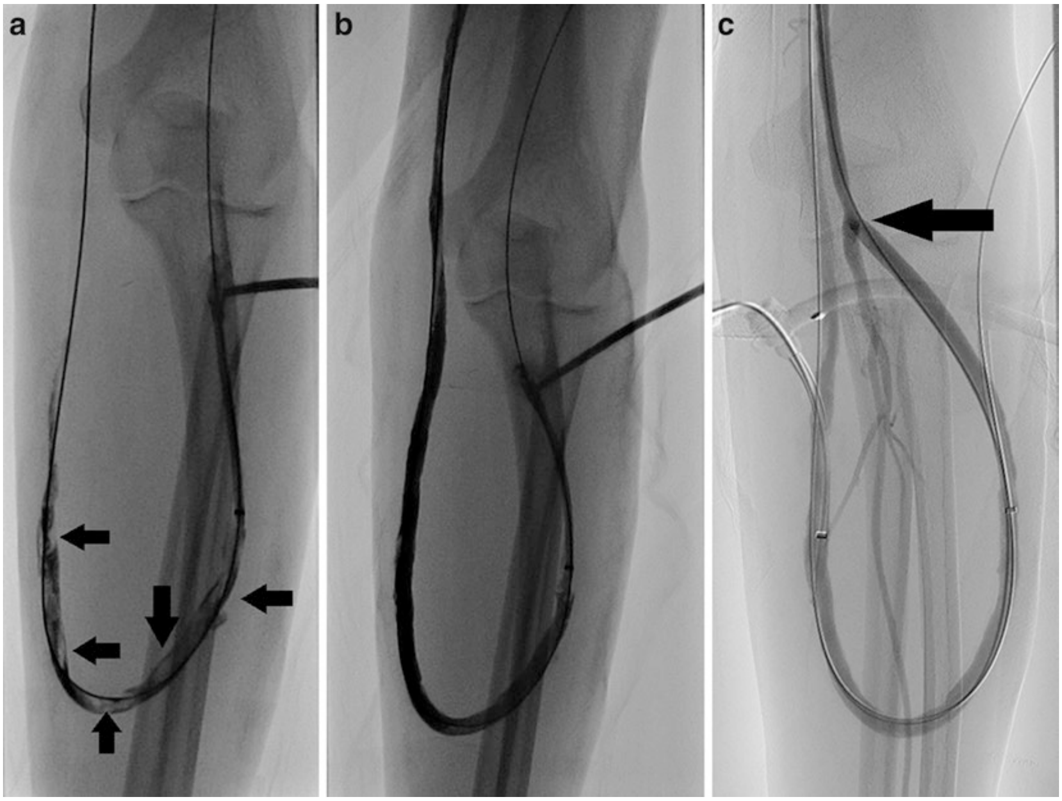


**Fig. 12.10** Patient with a brachiocephalic forearm loop graft. (**a**) After administration of tissue plasminogen activator to lyse clot and aspiration of clot, filling defects are seen within the graft representing residual clot (arrows). (**b**) Compared to image (**a**), residual clot has been cleared with balloon maceration. (**c**) The arterial plug has been pulled with a Fogarty balloon (not shown) with no residual clot seen from the arterial anastomosis (arrow) to the outflow cephalic vein

the access clot but will soften the remainder such that it can be fragmented and aspirated or safely pushed downstream using balloons (Fig. 12.10). A key point is to avoid pushing clots into the artery; grafts contain a limited clot burden of generally 3 ml [22].

In contrast, mechanical thrombectomy involves devices that fragment the clot with or without aspiration or the need for thrombolytics. Some of these devices include the AngioJet (Boston Scientific, Natick, MA), the Arrow-Trerotola PTD (Teleflex, Research Triangle Park, NC), and the Cleaner PTD (Argon Medical, Plano, TX).

## AVF Thrombectomy and Declotting

As with grafts, the key to success is treatment of all significant underlying stenoses and removal of all clots possible. Although techniques and devices used for declotting of fistulas and grafts are similar, there are several important differences. In contrast to grafts, fistulae can contain a much larger clot volume particularly in cases of patients with aneurysmal veins. Because of the caliber of these veins, the clot may need to be mobilized with balloon maceration and external manipulation. Further, this larger clot burden can portend a significant risk of procedure-related pulmonary embolism. Absolute care should be taken to prevent clot from being pushed into the feeding artery. Occasionally, the thrombosis may be limited to a short segment, and a simple angioplasty may restore flow. Primary patency after declotting should exceed 40% at 3 months. In patients with right-to-left intracardiac shunts, such as an atrial septal defect, graft and fistula thrombectomies carry increased risks of stroke and may be contraindicated.

## AVF and AVG Stents/Stent Grafts

Today, bare metal stents (BMS) have limited role in dialysis interventions. These are reserved for use in bailout situations where there is (1) rupture of the vein with continued extravasation that cannot be controlled with conservative measures or (2) flow-limiting spasm of the dilated site where there is a perceived risk of acute thrombosis. Conservative measures for extravasation include external compression of the bleeding site, reversal of heparin if administered, and balloon tamponade at the site of rupture. Stent grafts may be more suitable in each of these indications (Fig. 12.11). Bare metal stents may still have a role in central vein stenosis that has ceased to respond to angioplasty. Randomized trials have shown *no* benefit of routine

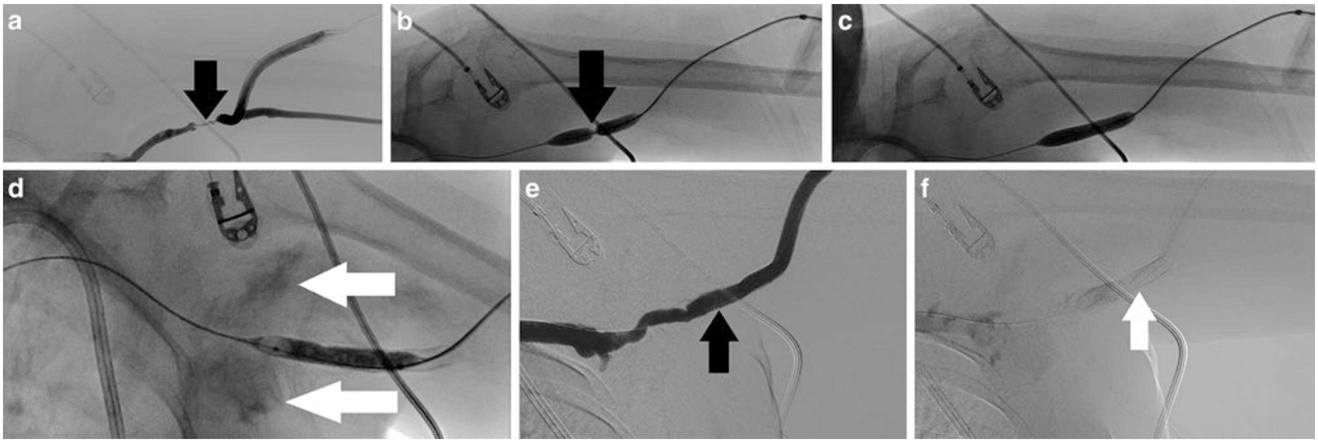


**Fig. 12.11** Patient with an upper arm brachiobasilic graft. (**a**) Critical stenosis at the venous anastomosis (arrow). (**b**) Focal waist in the balloon at the location of stenosis (arrow). (**c**) Balloon is completely effaced. (**d**) Contrast is seen in the soft tissues indicating rupture of the vein (arrows). The balloon has been reinflated across the venous tear in the area of treated stenosis to tamponade the bleeding with the hope of stopping it. (**e**) Conservation measures failed, and a stent graft (arrow) has been deployed across the venous tear successfully covering it as no extravasation is seen. (**f**) The appearance of the stent graft without contrast (arrow).

stenting compared to angioplasty for access patency following intervention [23–25].

Expanded tetrafluorethylene stent grafts have been assessed in multiple randomized clinical trials. The Flair, Fluency (Bard, Tempe, AZ), and VIABAHN (Gore, Flagstaff, AZ) stent grafts have proven more effective than angioplasty for treatment of venous anastomotic stenosis in dialysis grafts with 6-month patencies of 51% vs. 23% and 51.6% vs. 34.2%, respectively (primary patency – time from intervention to next intervention) [11, 12]. Recent data has supported the superiority of stent grafts over angioplasty for treating in-stent restenosis within bare stents: 66.4% versus 12.3% at 6 months, respectively [26].

**Key Point**
For venous anastomosis stenosis, stent grafts have proven superior to balloon angioplasty.

Drug-eluting balloons have shown benefit over conventional angioplasty in peripheral arterial interventions. Ongoing controlled trials are assessing their potential impact in native dialysis fistulae and outflow veins. Cryoplasty (ultra-low temperature angioplasty) and cutting balloons (containing cutting wire or blades), like bare metal stents, have not been shown to be more effective than angioplasty [10, 27].

## Central Venous Stenoses and Occlusions

Balloon angioplasty and bare metal stents yield poor primary patency in central venous stenosis. Technical success rates range from 70% to 100% with mean patency at 6 months ranging from 29% to 42% [28, 29]. There must be a clear clinical indication *and* >50% stenosis to warrant intervention. An asymptomatic central vein stenosis or occlusion is not an indication for treatment as accesses can function well in the setting of extensive collaterals. Symptoms include access dysfunction and extremity or neck and face swelling (Fig. 12.12). Moreover, clinically asymptomatic stenoses can become symptomatic after unnecessary intervention [30, 31].

The role of primary stent graft placement for treatment of central vein stenoses and occlusions is still under investigation. Some retrospective data has suggested their superiority over bare metal stents [32] (Fig. 12.13). In symptomatic cases warranting treatment, traversing the occlusion may require specialized tools beyond traditional catheter and

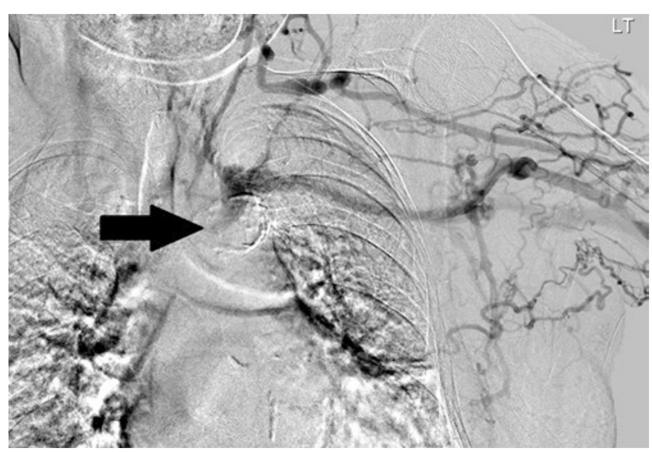


**Fig. 12.12** Extensive central venous collaterals resulting from left innominate vein occlusion (arrow). Despite the occluded main outflow, the patient had no access dysfunction and no clinical symptoms of central venous occlusion; therefore, no intervention was performed.

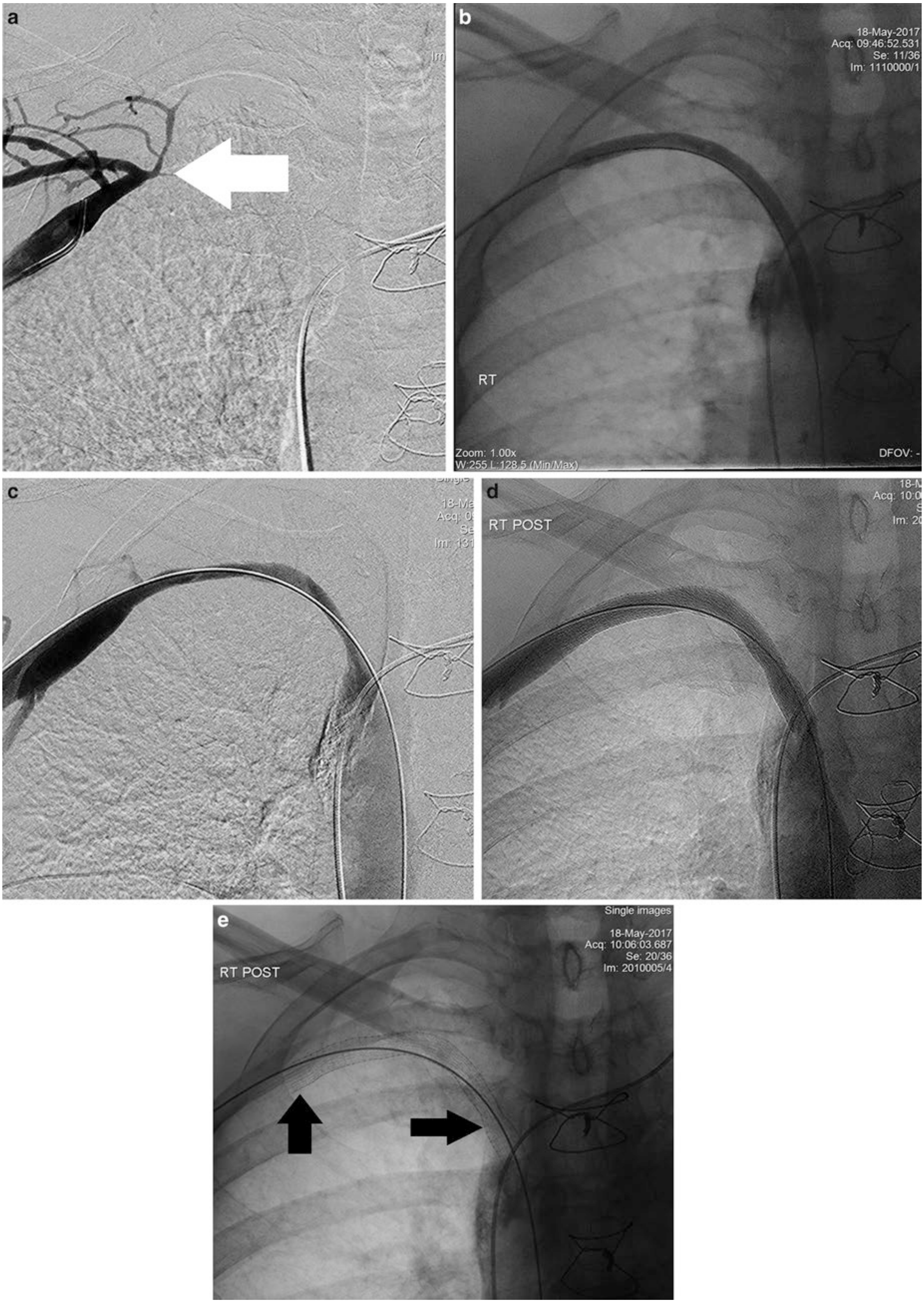


**Fig. 12.13** Patient with a right arm brachiocephalic fistula with arm swelling for 4 months. (**a**) Chronic occlusion of the right subclavian vein (arrow). (**b**) Using a vascular support catheter and a 0.014-inch crossing wire, the occlusion was traversed and dilated initially with a 4 × 80 mm balloon. (**c**) Fistulogram shows no extravasation. (**d**) A 9 × 80 mm stent graft was placed with the hope of improving long-term patency of the occlusion traversed. (**e**) Plain radiograph shows the stent graft extending from the subclavian vein to the SVC (arrows).

guidewire techniques. Those may include sharp needle recanalization, specialized guiding catheters, and radiofrequency guidewires.

> **Key Point**
> Avoid the "occulostenotic reflex." Do not treat the asymptomatic stenosis in the HD patient.

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