Dialysis Access and Recirculation

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Since its inception, hemodialysis has been bedeviled by problems of vascular access. Access, from the time of creation and throughout a patient's dialysis life, consumes significant time, effort, and expense and creates much anxiety and risk for patient and family. Vascular access complications remain the single leading cause of hospitalization and expense for dialysis patients. Some, such as infected access sites, are potentially life threatening. It is common for an access problem to precipitate a crisis related to the end of a patient's dialysis life. Despite the advances made in hemodialysis technology, the same vascular access problems that plagued dialysis pioneers continue today to confound patient care teams.

CHAPTER

5

Arteriovenous Dialysis Access: Evaluation and Placement

EVALUATION FOR HEMODIALYSIS VASCULAR ACCESS

- History
  - Surgical cutdown
  - Multiple peripheral catheters
  - Peripherally inserted central catheter line placement
  - Transvenous pacemaker
  - Axillary dissection
  - Intravenous drug use
  - Obesity
  - Peripheral vascular disease
  - Atherosclerotic disease
- Physical examination
  - Asymmetry of pulse
  - Asymmetry of blood pressure
  - Abnormal capillary refill
  - Abnormal Allen test
  - Presence of surgical or other scars

FIGURE 5-1

Evaluation for hemodialysis access. The creation of optimal vascular access requires an integrated approach among patient, nephrologist, and surgeon. The preoperative evaluation includes a thorough history and physical examination. A history of arterial and venous line placements should be sought. The upper extremities are examined for edema and asymmetry of pulse and blood pressure. Access should be placed at the wrist only after it is verified that the radial artery is not the dominant arterial conduit to the hand. The classic study is the Allen test, in which an observer compresses both the radial and ulnar arteries, has the patient exercise the hand by opening and closing to cause blanching, then releases one vessel to be certain that the fingers become perfused. An alternative, and perhaps more precise, test is to verify by Doppler imaging that flow to all digits is maintained despite occlusion of the radial artery. If indicated, vascular imaging studies should be used to delineate the vascular anatomy and rule out arterial or venous disease. Clinically silent stenosis involving the central veins is becoming increasingly common with the improved survival of critically ill patients for whom central vein catheters are commonplace.

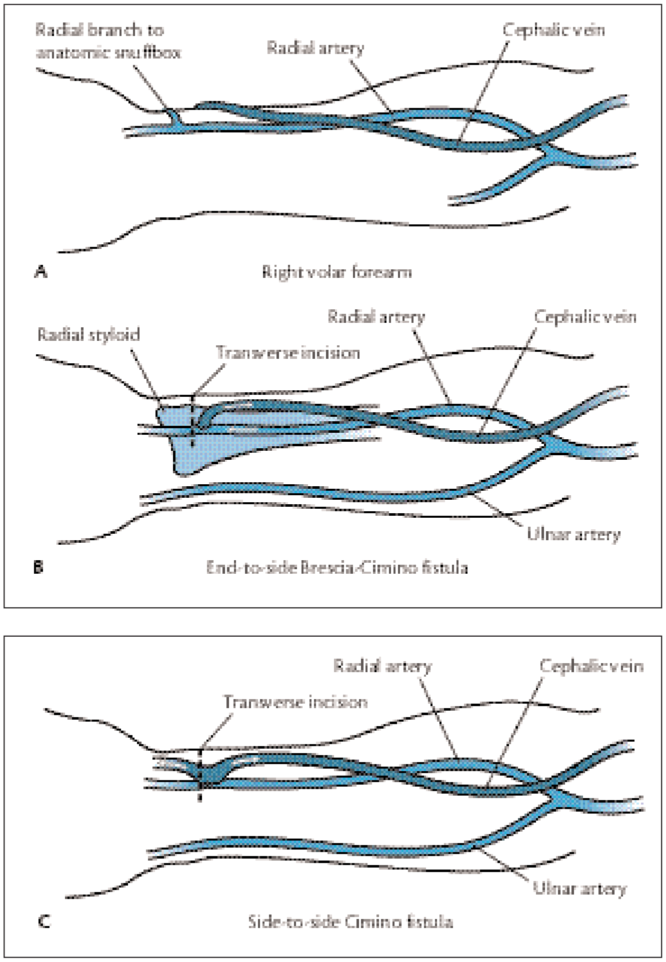


FIGURE 5-2

Creation of a Brescia-Cimino (radial-cephalic) fistula. The native vein arteriovenous fistula is the preferred choice for hemodialysis access. This simple and effective procedure, in which an artery is connected to an adjacent vein to provide a large volume of blood flow into the superficial venous system, has become less common in recent years. The ideal artery has minimal wall calcification, so that dilation can occur with time and allow unimpeded flow. In addition, the artery should not be affected by proximal stenosis, the most common site being an ostial lesion in the subclavian artery. Ideally, the outflow vein is subjected to minimal dissection or manipulation during the surgical procedure. Forcible distension of veins and rough handling of arteries leads to formation of neointimal fibrous hyperplasia and localized stenosis.

The first autogenous access site described was radial-cephalic at the level of the radial styloid process. These can be constructed end-vein to side-artery, **A** and **B**, or side-to-side, **C**, between the two vessels. The exposure is conveniently obtained using a transverse incision at the wrist, just proximal to the radial styloid process, where the artery and cephalic vein lie close to one another. In general, the two vessels are just far enough apart so that an end-to-side technique is best. When the vessels overlie each other, some surgeons prefer the side-to-side technique, which allows reversal of blood flow into the dorsum of the hand and then via collaterals into the forearm, theoretically leading to better flow volume over time.

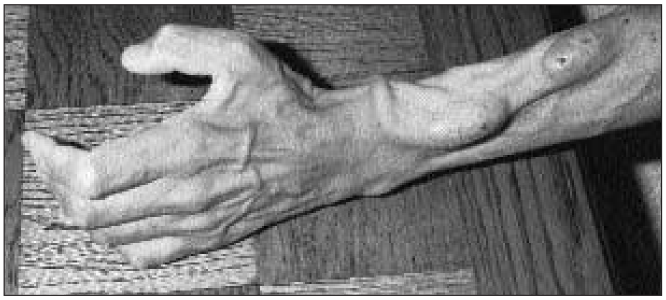
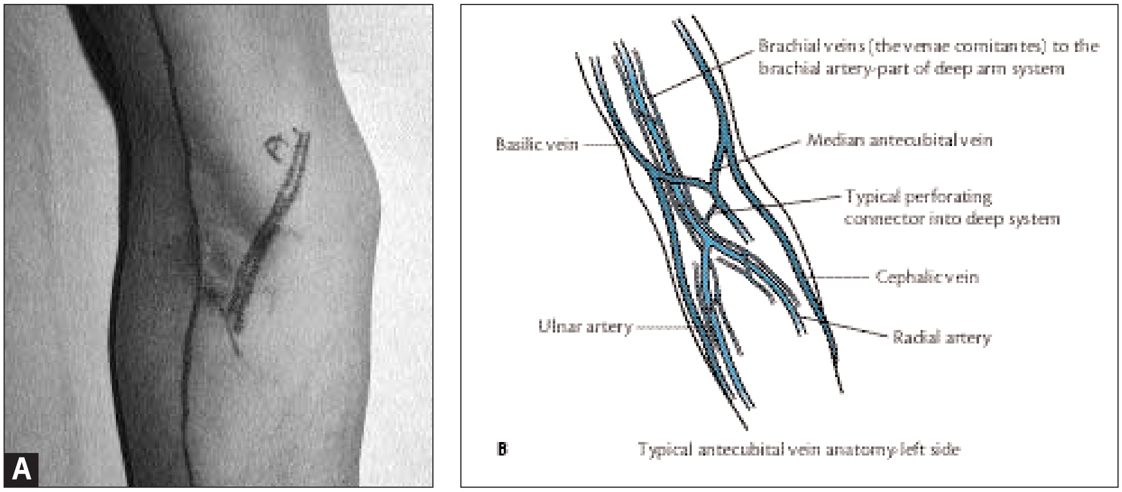


FIGURE 5-3

The Brescia-Cimino (radial-cephalic) fistula. The radial-cephalic fistula offers many advantages. It is simple to create and preserves more proximal vessels for future access construction. The lower incidence of steal is likely the result of the lower flow rate associated with these accesses. Additionally, such accesses have low rates of thrombosis and infection. The photograph shows a mature Brescia-Cimino fistula in a patient with longstanding diabetes. The fistula outflow vein has numerous aneurysmal segments, and, although they are associated with some tendency toward flow stagnation, they are of no harm to the patient's dialysis life. They do, however, become obvious targets for the dialysis technical staff, who have a tendency to puncture them repeatedly rather than to utilize new needle insertion sites. The patients arm also demonstrates marked muscle atrophy secondary to advanced diabetic neuropathy, which particularly involves the thenar eminence and the interosseus muscle groups. Complaints of weakness and loss of grip strength in the arm are common and may represent symptoms of steal. In this case, however, the symptoms are due to the intrinsic loss of muscle mass, rather than to steal.



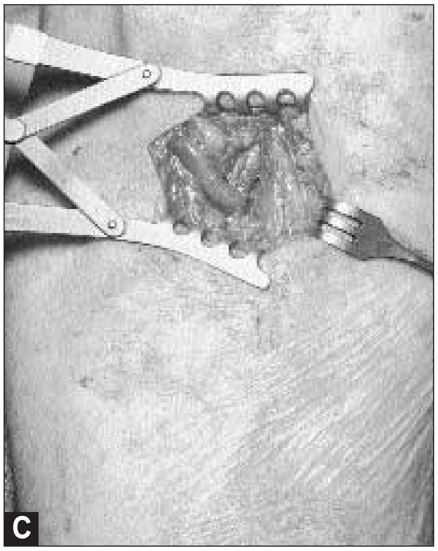


FIGURE 5-4

The brachial-cephalic vein fistula. If a radial-cephalic vein fistula cannot be constructed, the next best choice for vascular access is the brachial-cephalic vein fistula. Accesses that utilize the brachial artery have the advantage of higher blood flow rates than those that use the radial artery. Although this may improve the efficiency of hemodialysis, it is also associated with increased risk of arm edema and steal. **A**, The native anatomy of the antecubital veins somewhat resembles the letter M. A more complete depiction is seen in **B**. The medial volar venous flow enters the basilic system; lateral volar flow enters the cephalic system; and the central connector, which includes a deep tributary, connects the brachial (venae comitantes) system at the brachial artery bifurcation. To create an antecubital autogenous site, there are two general approaches; the surgeon either mobilizes the cephalic vein directly into the brachial artery (**C**) or "anastomoses" the deep connector between the median antecubital vein and the brachial veins directly to the adjacent artery. It is also possible to prepare a native vein arteriovenous fistula in the antecubital fossa by transposing brachial or basilic veins from the deeper compartment of the brachium to the subcutaneous tissue.

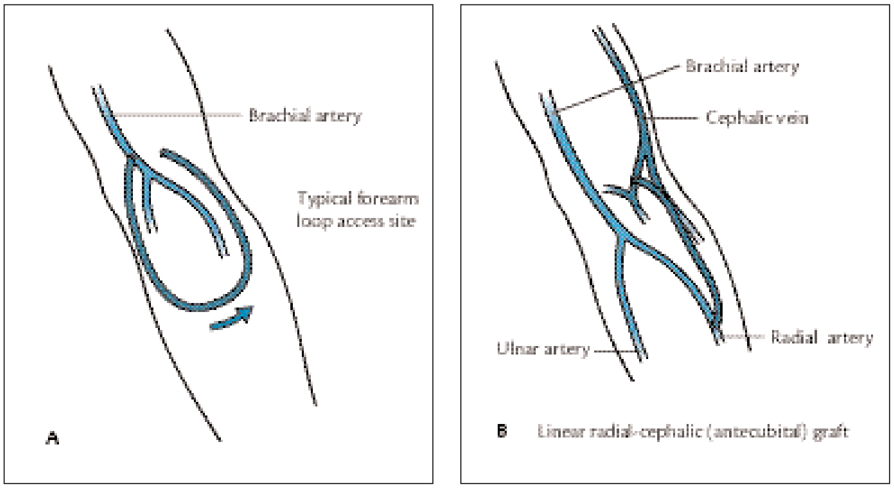


FIGURE 5-5

Polytetrafluoroethylene (PTFE) vein graft. The most common synthetic material used for dialysis access construction is the PTFE conduit. This material replaced bovine heterografts; alternative materials such as the umbilical vein graft have not yet made much headway. Because of the infection risk, Dacron bypass grafts have never functioned well for dialysis. PTFE is an inert material that is formed into a pliable conduit. Its ultramicroscopic structure is a series of nodes connected by tiny filaments, leaving pores whose size can be varied during manufacture. The process of healing after implantation involves ingrowth of fibroblasts into the pore structure, giving a final graft-tissue amalgam that is "incorporated" when encountered by the surgeon for revision. There is virtually no neovascularization through the pores, which are too small for capillary ingrowth. In humans, neointima grow along the graft for no more than 3 cm from the anastomosis. In animal models, neointima can be much more robust, growing along most of the length of the graft and providing it with greater resistance to thrombosis. Typical layouts for the construction of a PTFE access site are **A**, the forearm loop, and **B**, linear forearm graft, respectively. Alternative sites include upper arm loop grafts, groin grafts, axillary artery-to-vein grafts, and a variety of other constructions. The sites of choice are limited by the requirements of hemodialysis: delivery of a high rate of blood flow and accessibility to the dialysis staff for cannulation with an adequate length of graft to keep the needles sufficiently separated and allow rotation of cannulation sites.

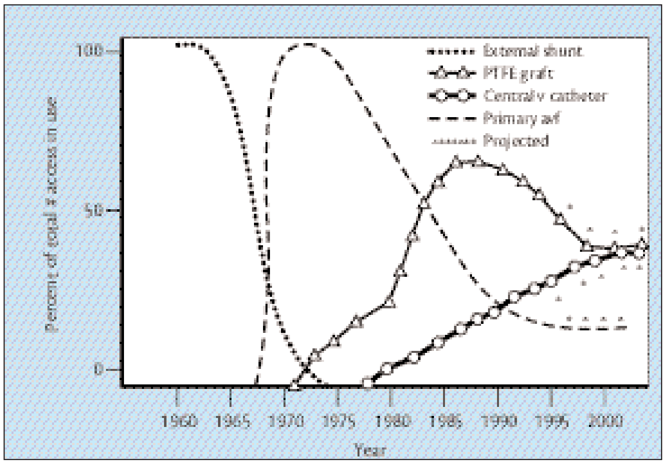


FIGURE 5-6

Trends in dialysis access sites. Despite our understanding of hemodialysis access and the advantages and disadvantages of the various options available, there is an alarming trend away from the use of native vein fistulas. Of even more concern is the increasing number of patients who begin dialysis without a permanent vascular access in place and the increasing prevalence of central vein catheters. It is not clear whether these trends are the result of age, comorbid conditions such as diabetes and peripheral vascular disease, or simply the untoward effect of late nephrology referral. Although central vein catheters were initially designed for temporary use while an arteriovenous vascular access was being constructed, improvements in design have led to their being used for permanent dialysis access. Nevertheless, central vein catheters, while popular with patients because they obviate "being stuck," are the source of a variety of access complications, including infection, central vein stenosis, and thrombosis.

Complications of Arteriovenous Dialysis Access Placement

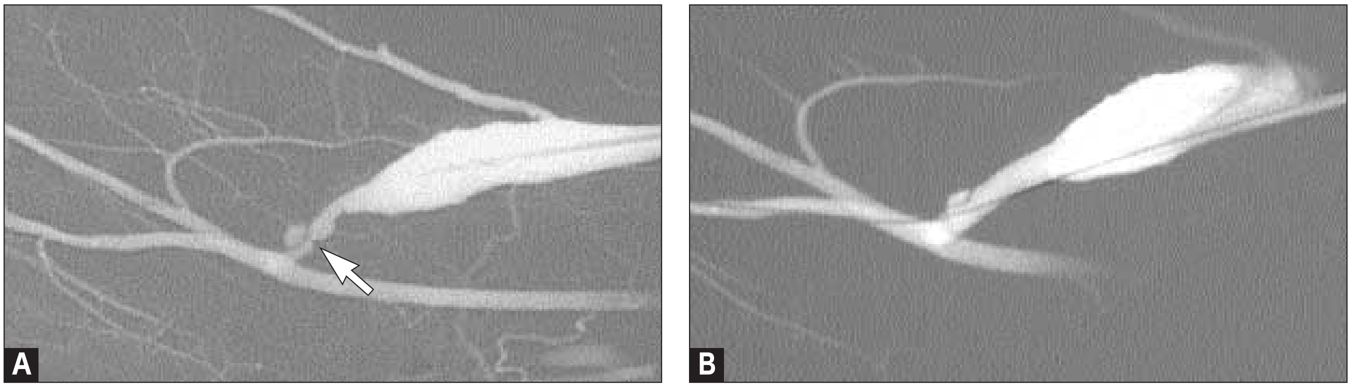


FIGURE 5-7

Arteriovenous fistula anastomotic stenosis. Arteriovenous fistulas exhibit better long-term patency compared with polytetrafluoroethylene (PTFE) grafts. **A**, This arteriogram, performed by injecting the brachial artery, demonstrates an end-to-side arteriovenous fistula involving the brachial artery and the cephalic vein. The *arrow* indicates an area of narrowing adjacent to the anastomosis, the most common site for a stenotic lesion in native vein fistulas. **B**, Angioplasty successfully eliminated the anastomotic stenosis. Limitations on balloon size are often encountered when treating lesions in arteriovenous fistulas because a portion of the balloon must often extend into the donor artery, which typically is of smaller diameter than the outflow vein.

FIGURE 5-8

Exposed polytetrafluoroethylene (PTFE) graft. Proper placement of a PTFE graft is crucial for its long-term survival. The graft cannot be too short, as it will deteriorate quickly from puncture limited to only a few sites; if it is too long, however, it will have a greater impedance to flow and a tendency toward thrombosis. The graft should be neither too deep to the skin nor too shallow. When the graft is too shallow, puncture by the dialysis staff is easier, but the skin may be eroded with scarring from repeated use. This photograph shows a linear forearm graft with a segment of exposed PTFE. An exposed graft is a serious problem for several reasons. First, exposure of actual puncture holes eventually leads to hemorrhage. Second, an exposed graft is, by definition, infected. Although some cases have been treated successfully with rotational skin flaps and a long course of antibiotics, the majority do not heal. The ideal treatment is removal of the segment of exposed graft, splicing a segment of new PTFE away from the site of exposure, and allowing secondary wound healing.

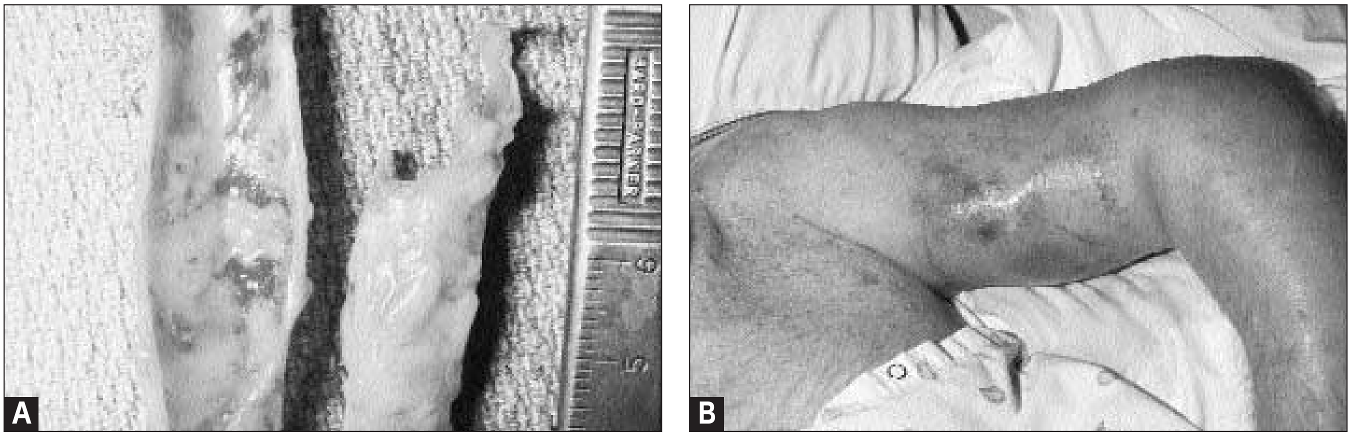


FIGURE 5-9

Extravasation injury to the access site. **A**, A relatively fresh segment of polytetrafluoroethylene graft was removed during a revision procedure. There is virtually no fibrosis or calcification (associated with repeated puncture). The luminal surface displays the results of multiple sites of puncture and healing. Among the most dramatic and troublesome complications of dialysis is access infiltration. In most cases the infiltration is minor and usually results from either inadequate hemostasis at the end of dialysis or needle perforation through the access site. Extravasation injury to the access is more likely when a needle errantly transfixes a graft or vein or when it accidentally becomes dislodged into the subcutaneous tissue. The venous return needle presents the biggest problem. In the face of typical pump speeds of 400 to 500 mL/min a potentially huge volume of fluid can enter the soft tissue before the pump stops in response to the alarm for elevated venous pressure. In many cases, the graft is unusable for weeks after such an episode. Continued use of the access in this setting may result in loss of the access site. **B**, In this example, the infiltration was composed of approximately 400 mL of priming crystalloid and blood, located both deep and superficial to the investing fascia of the arm. The access remained patent and was eventually restored to function; however, a series of percutaneous drainage procedures and open drainage were necessary. Compartment syndrome, with loss of distal motor function or sensation in the arm, is another concern in this setting, and drainage must be performed to treat this surgical emergency.

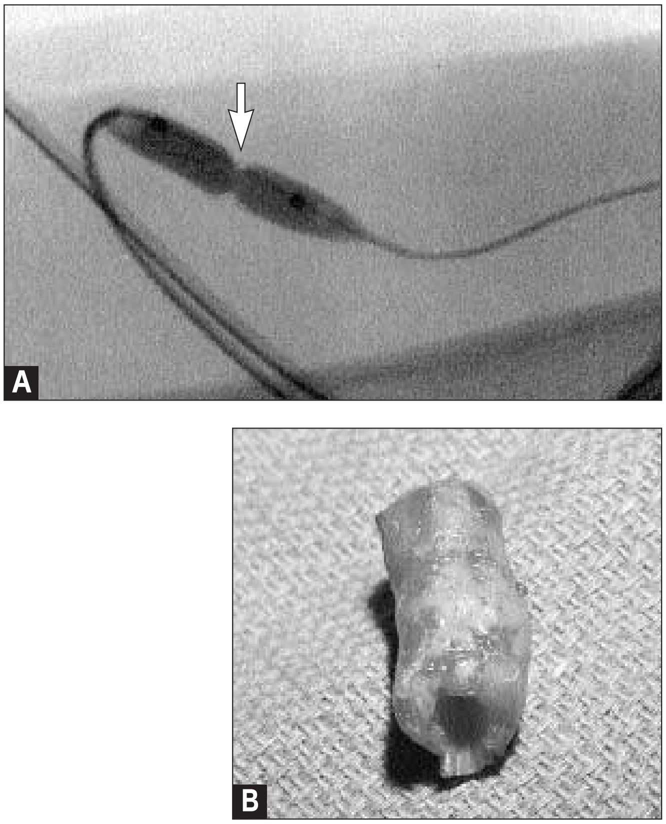


FIGURE 5-10

Outflow vein stenosis. Stenotic lesions are most often found at a polytetrafluoroethylene (PTFE) graft's venous anastomotic site or within its outflow vein. **A**, Radiograph depicting an angioplasty balloon inflated across an outflow vein with a stenotic lesion. The "waist" in the balloon (*arrow*) indicates the location of the stenosis. With increasing inflation pressure the waist disappears, an indication of successful angioplasty. Failure to eliminate the waist in the balloon indicates incomplete dilatation of the lesion. Occasionally, outflow vein stenoses are very resistant to dilatation and require high inflation pressures. This is not surprising given the amount of scarring and intimal hyperplasia that can develop in a dialysis access site. **B**, Resected graft-venous anastomosis from a one-year-old PTFE graft. The vein wall seen here is enormously thickened. Angioplasty of lesions such as these is often unsuccessful, as this rigid material is likely to rebound to its stenotic state with any manipulation.

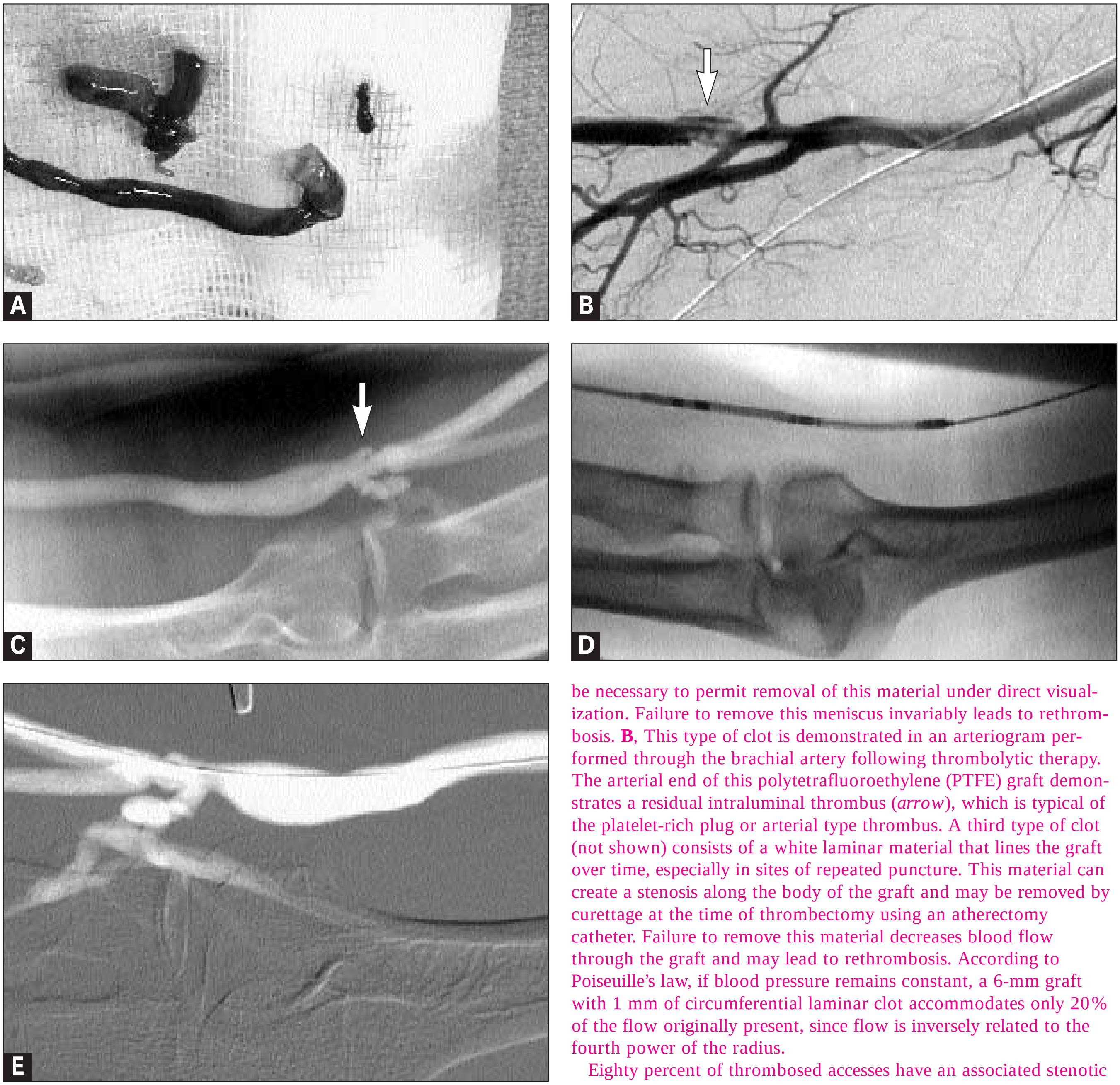


FIGURE 5-11

Graft thrombosis due to outflow vein stenosis requiring use of an atherectomy catheter. Thrombectomy of a dialysis access site involves removal of three types of clot. **A**, The body of a thrombosed access contains a red or purplish thrombus that is often gelatinous. It is easily removed with a balloon-tipped thrombectomy/embolectomy catheter. This photograph also demonstrates the small meniscus of firm, laminar, platelet-rich clot that usually obstructs arterial inflow. On occasion, it is also found at the venous end. This type of clot can be tenacious and may not be removed with thrombolytic therapy or the balloon catheter. A cutdown at the arterial end of the graft may be necessary to permit removal of this material under direct visualization. Failure to remove this meniscus invariably leads to rethrombosis. **B**, This type of clot is demonstrated in an arteriogram performed through the brachial artery following thrombolytic therapy. The arterial end of this polytetrafluoroethylene (PTFE) graft demonstrates a residual intraluminal thrombus (*arrow*), which is typical of the platelet-rich plug or arterial type thrombus. A third type of clot (not shown) consists of a white laminar material that lines the graft over time, especially in sites of repeated puncture. This material can create a stenosis along the body of the graft and may be removed by curettage at the time of thrombectomy using an atherectomy catheter. Failure to remove this material decreases blood flow through the graft and may lead to rethrombosis. According to Poiseuille's law, if blood pressure remains constant, a 6-mm graft with 1 mm of circumferential laminar clot accommodates only 20% of the flow originally present, since flow is inversely related to the fourth power of the radius.

Eighty percent of thrombosed accesses have an associated stenotic lesion. **C**, An eccentric focal stenosis is demonstrated at the anastomosis of a PTFE forearm graft and its outflow vein (*arrow*), which did not respond to percutaneous transluminal angioplasty. The lesion was subsequently resected using a Simpson atherectomy catheter, which consists of a concealed cutting chamber that is deflected into contact with the stenotic lesion of the vessel wall by inflating the associated balloon. With the lesion projecting into the cutting chamber, a high-speed cylindrical cutting blade resects tissue into a collecting chamber. This chamber is rotated sequentially until the circumference of the lesion has been treated. **D**, The Simpson atherectomy catheter is placed across the stenotic lesion. **E**, The postprocedure venogram shows that the lesion was successfully resected.

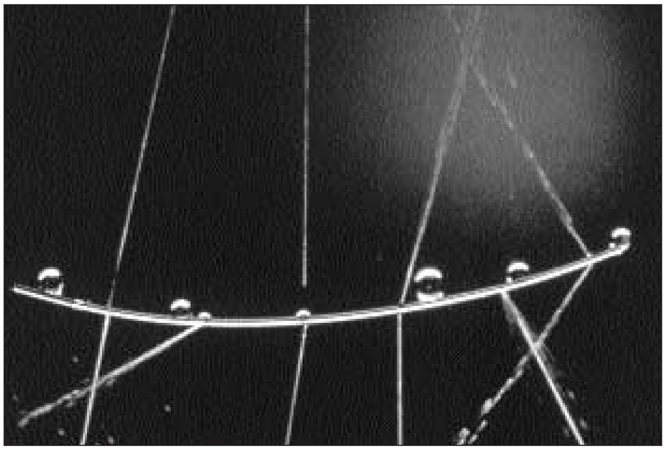


FIGURE 5-12

Pulse spray catheter. To increase the efficiency of drug thrombolysis, pulse spray catheters are often used. The technique involves embedding the catheter within the clot and intentionally obstructing the catheter end hole with a guidewire. When the fibrinolytic agent is injected, it is forced out through the catheter sideholes in jets and permeates the clot. With this method, a larger surface area of clot is exposed to the fibrinolytic agent.

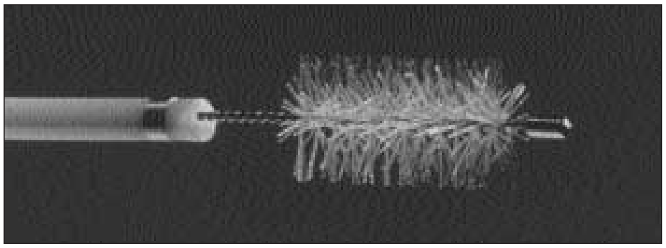


FIGURE 5-13

Thrombectomy brush. Several types of mechanical thrombectomy devices have been developed as alternatives to pharmaceutical fibrinolysis. All mechanically macerate or disrupt clot into small fragments that embolize into the central veins and, eventually, the pulmonary vascular bed. This photograph demonstrates a brush attached to a motor drive that imparts high-speed rotary motion to disrupt the thrombus. The danger of most mechanical devices is the risk of vascular injury.

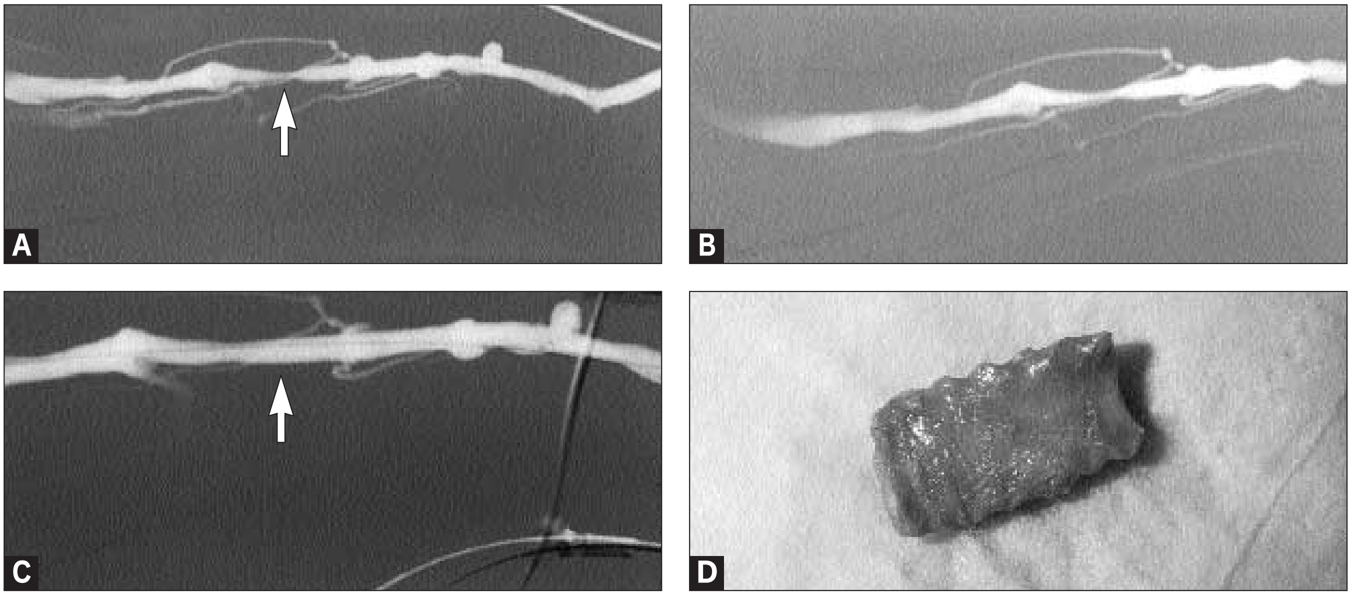


FIGURE 5-14

Outflow vein stenosis with stenting. **A**, Arteriography in this patient with a Brescia-Cimino fistula demonstrates stenosis of the outflow vein approximately 15 cm central to the fistula (*arrow*). **B**, Percutaneous transluminal angioplasty was performed in this patient; however, because of immediate elastic recoil, the lesion looks no different after angioplasty. **C**, Following stent placement (*arrow*), there is no residual stenosis, and good flow through the stent is apparent. Stents have proven controversial in access sites. Although they may improve patency in central vein stenoses (*vide infra*), in the periphery they may be a hindrance. Some patients develop vigorous fibrosis at the venous site of a stent. **D**, This photograph demonstrates what had occurred only 1 month after stent placement. Stents can be a problem when dealing with subsequent vascular access dysfunction. During thrombectomy, the tiny wires of a stent can puncture balloon catheters. When stented segments restenose, it is impossible to perform open patch angioplasty over such segments, and it becomes necessary to jump to a different venous outflow site. It is not clear whether stents in or adjacent to dialysis grafts are cost effective in maintaining graft patency.

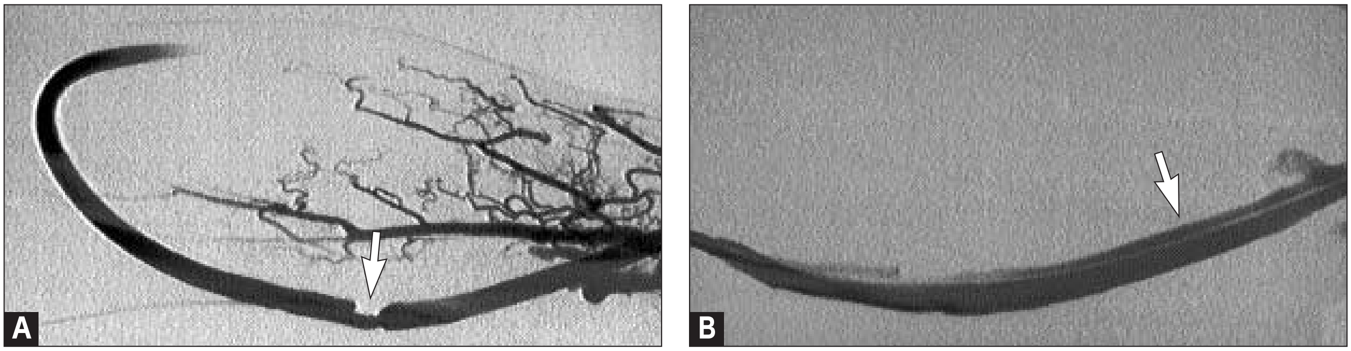


FIGURE 5-15

Intragraft stenosis. **A**, This arteriogram demonstrates a forearm loop polytetrafluoroethylene (PTFE) graft with an intragraft stenosis (*arrow*). Stenotic lesions in this site are less common than those involving either the venous anastomosis or the outflow vein. **B**, These lesions can be treated successfully with percutaneous transluminal angioplasty (*arrow*). In cases where angioplasty is unsuccessful, intragraft stenoses can also be treated using percutaneous atherectomy or surgical revision. Since this region of the access is subject to needle cannulation, the placement of a stent would be inadvisable. Intragraft stenoses may be located between the sites of the arterial and venous needle placements during dialysis. If so, the most common screening studies, namely venous pressure measurements and recirculation, do not have abnormal findings and the lesion may remain undetected until access thrombosis develops.

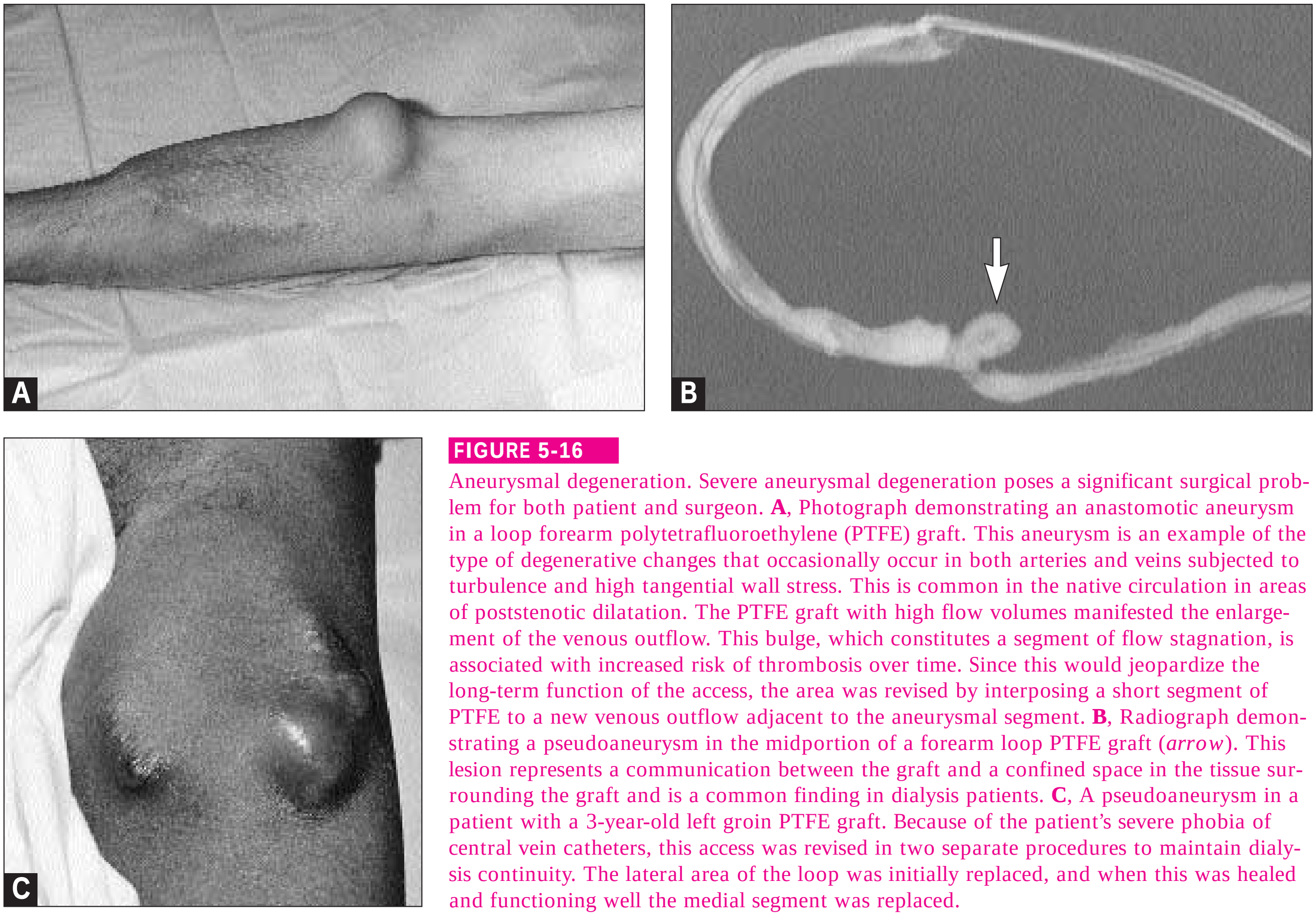


FIGURE 5-16

Aneurysmal degeneration. Severe aneurysmal degeneration poses a significant surgical problem for both patient and surgeon. **A**, Photograph demonstrating an anastomotic aneurysm in a loop forearm polytetrafluoroethylene (PTFE) graft. This aneurysm is an example of the type of degenerative changes that occasionally occur in both arteries and veins subjected to turbulence and high tangential wall stress. This is common in the native circulation in areas of poststenotic dilatation. The PTFE graft with high flow volumes manifested the enlargement of the venous outflow. This bulge, which constitutes a segment of flow stagnation, is associated with increased risk of thrombosis over time. Since this would jeopardize the long-term function of the access, the area was revised by interposing a short segment of PTFE to a new venous outflow adjacent to the aneurysmal segment. **B**, Radiograph demonstrating a pseudoaneurysm in the midportion of a forearm loop PTFE graft (*arrow*). This lesion represents a communication between the graft and a confined space in the tissue surrounding the graft and is a common finding in dialysis patients. **C**, A pseudoaneurysm in a patient with a 3-year-old left groin PTFE graft. Because of the patient's severe phobia of central vein catheters, this access was revised in two separate procedures to maintain dialysis continuity. The lateral area of the loop was initially replaced, and when this was healed and functioning well the medial segment was replaced.

FIGURE 5-17

Vascular steal. Vascular steal is a common problem of dialysis access sites. The principle of steal is related to two phenomena: 1) calcification or stenosis in the inflow arterial segment proximal to an access site (so that the native artery cannot dilate to meet the increasing demands for flow volume); 2) and an outflow arterial bed in parallel to the fistula origin with higher net vascular resistance than the fistula conduit. If both of these are present, blood flow is diverted to the access site in association with a drop in perfusion pressure to the most acral tissues, the fingers. When steal is severe, trauma to the digits leads to gangrene. Several treatment strategies are available to the surgeon. The access can be "banded," or purposefully stenosed at its origin to divert flow to the ischemic site. The access can be revised using a tapered graft or the point of origin of the access can be moved more proximally in the arterial tree, in the hope of allowing full flow without diverting distal perfusion pressure. Additionally, one can perform a variety of bypass procedures to divert higher-pressure proximal blood to increase distal perfusion pressure. In severe cases, either the access or the distal digits may be sacrificed to preserve the other.

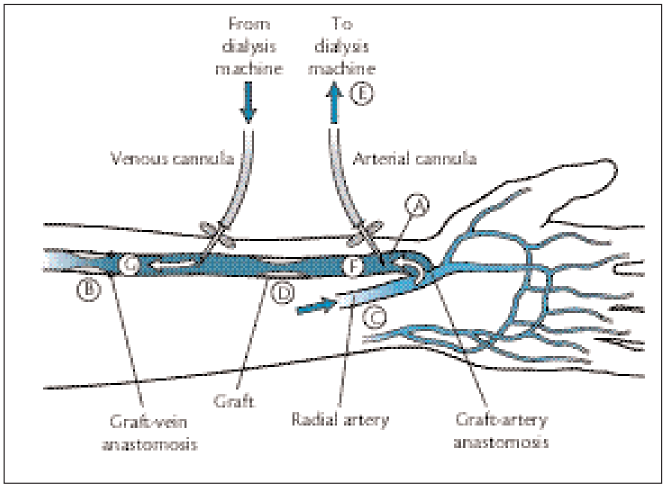


FIGURE 5-18

Vascular access screening methods. Dialysis grafts have a high incidence of thrombosis, the risk of which increases when graft flow rates (*A*) fall below 600 to 700 mL/min, particularly with stenotic lesions in or near the graft. Most often, stenoses occur just distal to the graft-vein anastomosis (*B*) but they can occur proximal to the graft-artery anastomosis (*C*) or within the graft itself (*D*). Various screening methods may help detect grafts at high risk for thrombosis at a point where graft revision (surgical or radiologic) may increase its longevity.

Measurement of graft blood flow (using Doppler imaging, ultrasound dilution, or another method) is increasingly available and may be the best screening method. When graft flow declines below dialyzer blood flow (*E*), blood flows between the needles (*F*) in a retrograde direction. This development is called recirculation, since it results in repeated uptake and dialysis of blood that has just been dialyzed. Recirculation can be detected by finding evidence that blood from the venous cannula is being taken up by the arterial cannula. This is most often recognized by the finding of an arterial blood urea nitrogen value below that in blood entering the graft.

A stenotic lesion in an outflow vein tends to increase the pressure in the vein and graft (*G*) between the stenosis and the venous needle. This pressure usually ranges from 25 to 50 mm Hg but may increase to more than 70 mm Hg in the presence of stenosis. This pressure can be measured directly or can be estimated from the venous pressure monitor on the dialysis machine at zero blood flow (adjusting for the difference in height between the graft and the transducer). To increase accuracy, this pressure can be normalized by dividing it by the mean arterial pressure. More commonly, this intragraft pressure is determined indirectly by using the dialysis machine's pressure transducer and a pump speed of 200 mL/min. In this case the measured pressure often exceeds 100 mm Hg in a normal graft, owing to the resistance in the venous needle.

Central Venous Dialysis Access

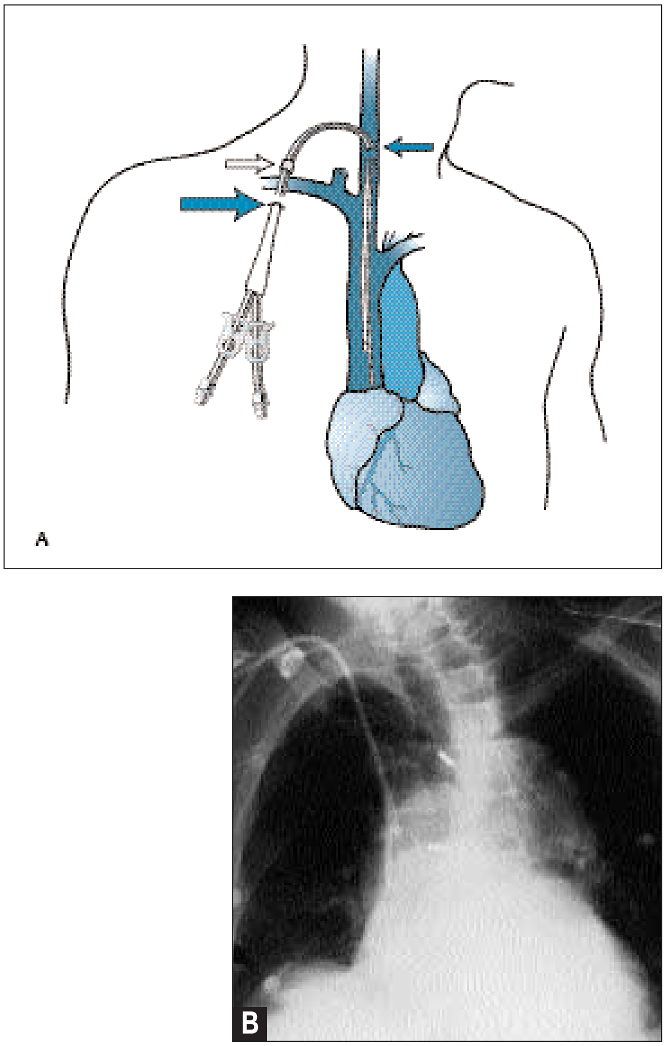


FIGURE 5-19

Right internal jugular vein catheters. The use of central vein catheters has grown significantly over the past several years. These catheters were at one time used only on a temporary basis and served as a "bridge" to permanent vascular access. Improvements in catheter design and function combined with ease of insertion have increased use of central vein catheters in dialysis units. To minimize the risk of central vein stenosis and subsequent thrombosis, central vein catheters should be inserted preferentially into the right internal jugular vein, regardless of whether they are being used for temporary or more permanent purposes. The typical positioning of a double-lumen catheter, **A**, is with its tip at the junction of the right atrium and the superior vena cava. The catheter has been "tunneled" underneath the skin so that the exit site (*large arrow*) is located just beneath the right clavicle and distant from the insertion site (*small arrow*). This catheter also has a cuff into which endothelial cells will grow and produce a biologic barrier to bacterial migration. **B**, Chest radiograph showing a dialysis central vein catheter that is composed of two separate single-lumen catheters that have been inserted into the right internal jugular vein. The distal tip of the venous catheter is positioned just above the right atrium. Care must be taken, however, to ensure proper placement of catheters with this type of design, because the two single lumens are radiographically indistinguishable.

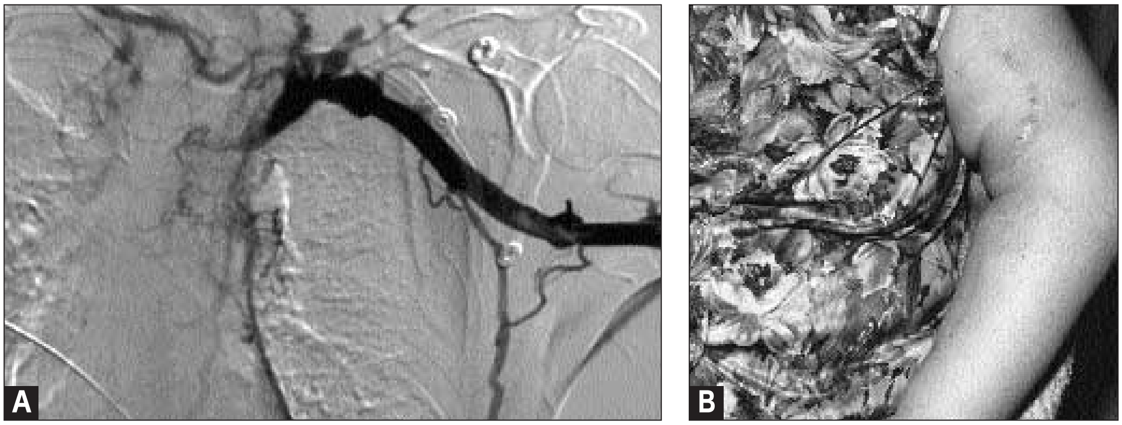


FIGURE 5-20

Central vein stenosis. **A**, Venogram of the central outflow veins performed in a patient with a left upper extremity polytetrafluoroethylene graft and arm edema, **B**.

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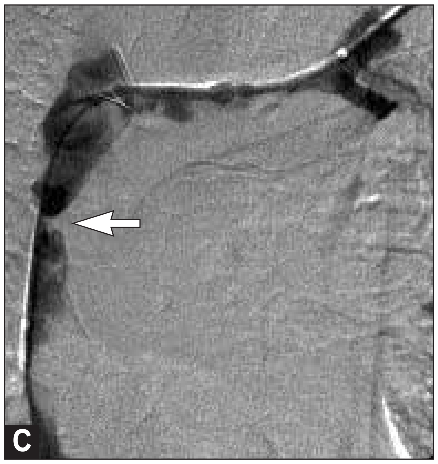

FIGURE 5-20 *(Continued)*

The angiogram (*Panel A*) demonstrates complete occlusion of the innominate vein (*arrow*) with collateral filling in the neck and the chest. The most common cause for stenosis or thrombosis of the central venous system is previous injury from indwelling central vein catheters. Central vein stenosis may not become apparent until an arteriovenous anastomosis is created. This increases blood flow in the outflow veins and may overwhelm a compromised central vein, resulting in the appearance of superficial collateral veins on the neck and chest wall in addition to ipsilateral arm edema. In this example, the occlusion was crossed using an angiographic catheter, and thrombolytic therapy was administered. **C**, Venography performed after thrombolysis demonstrates severe stenosis of the innominate vein and the superior vena cava (*arrow*).

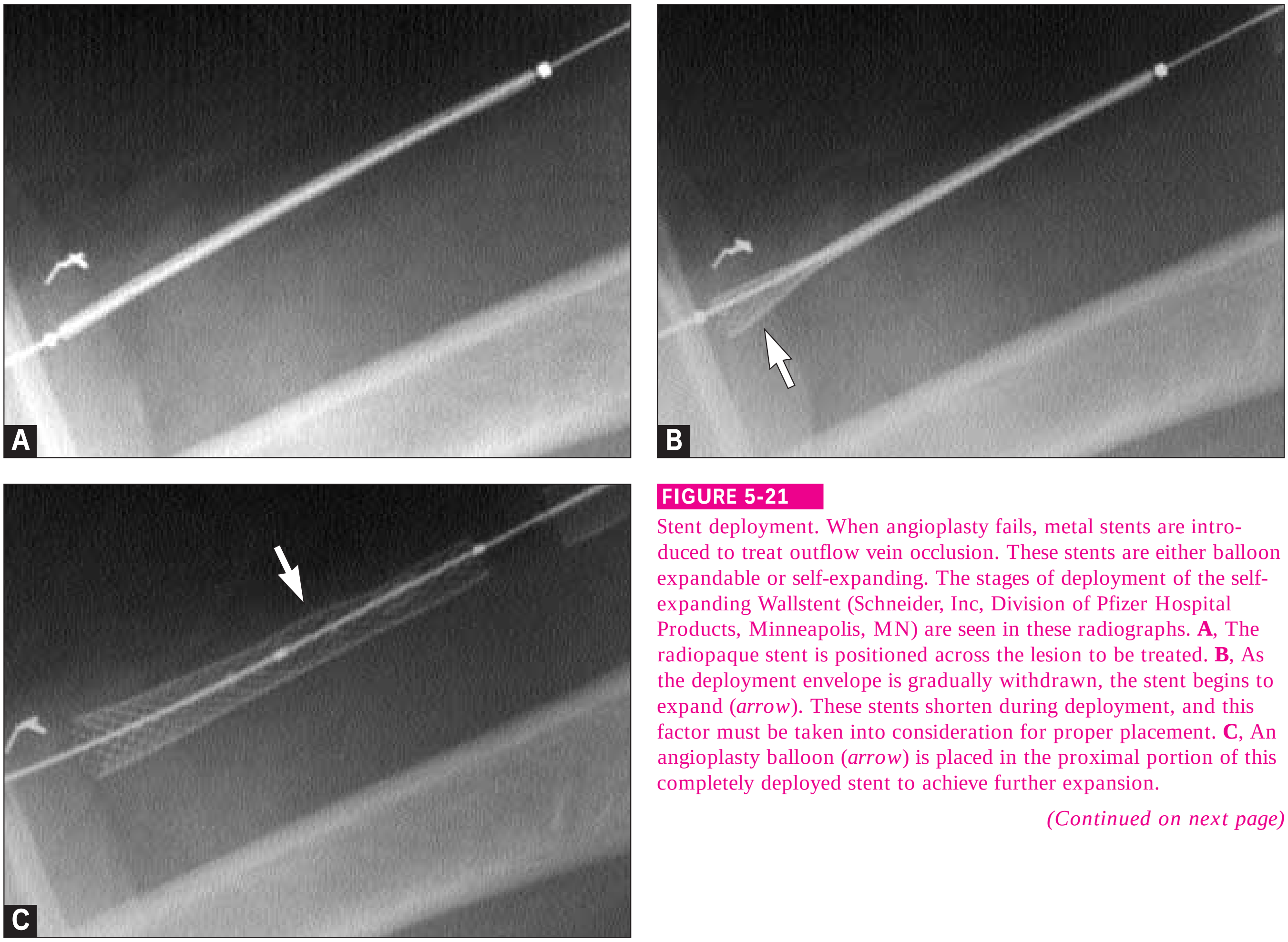

FIGURE 5-21

Stent deployment. When angioplasty fails, metal stents are introduced to treat outflow vein occlusion. These stents are either balloon expandable or self-expanding. The stages of deployment of the self-expanding Wallstent (Schneider, Inc, Division of Pfizer Hospital Products, Minneapolis, MN) are seen in these radiographs. **A**, The radiopaque stent is positioned across the lesion to be treated. **B**, As the deployment envelope is gradually withdrawn, the stent begins to expand (*arrow*). These stents shorten during deployment, and this factor must be taken into consideration for proper placement. **C**, An angioplasty balloon (*arrow*) is placed in the proximal portion of this completely deployed stent to achieve further expansion.

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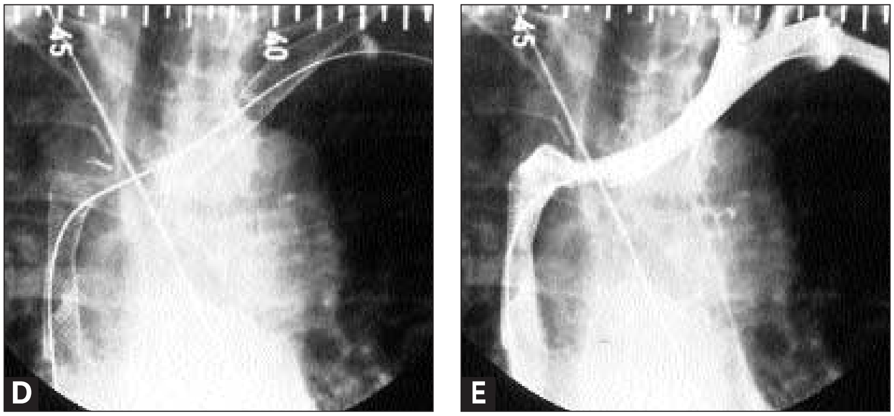

FIGURE 5-21 *(Continued)*

D, To improve central vein patency following angioplasty, metal stents have been placed in the innominate vein and the superior vena cava. **E**, A postprocedure venogram demonstrates no residual stenosis.

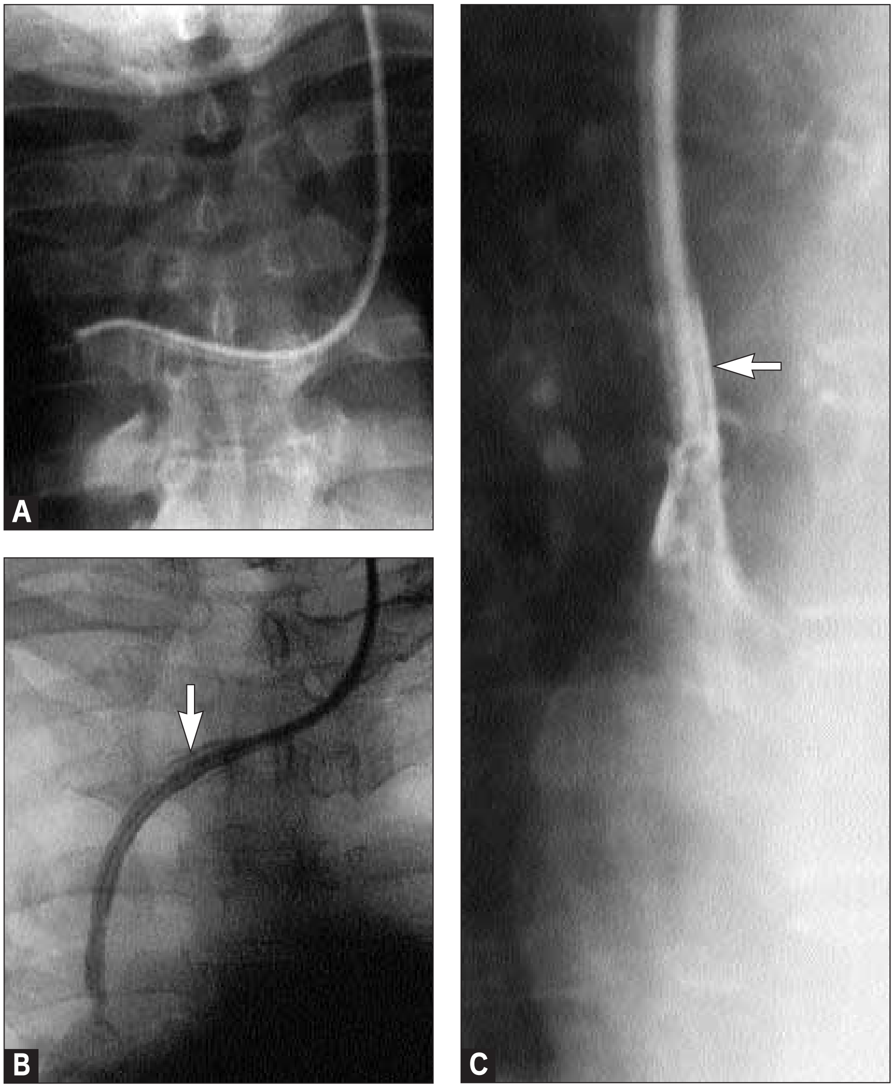

FIGURE 5-22

Central vein catheter complications. **A**, This radiograph demonstrates the tip of this dialysis catheter abutting the wall of the left innominate vein at its junction with the superior vena cava. To maintain adequate dialysis flow rates and minimize fibrin sheath formation, it is important for the catheter tip to be in the superior vena cava, near or in the right atrium. **B** and **C**, Injection of contrast through these dialysis catheters demonstrates the contrast outlining the outside of the distal portion of the catheter (*arrows*). This finding is characteristic of a fibrin sheath with contrast medium trapped between the fibrin sheath and the outer wall of the catheter. Fibrin sheaths are associated with a reduction (often severe) in the achievable blood flow rate and, as a result, inadequate dialysis delivery. They can be lysed by instilling large doses of urokinase (typically 250,000 units) through the catheter ports. If thrombolytic therapy is unsuccessful, the fibrin sheath can be stripped using a snare loop. Although these catheters can function remarkably well, they are prone to thrombosis.

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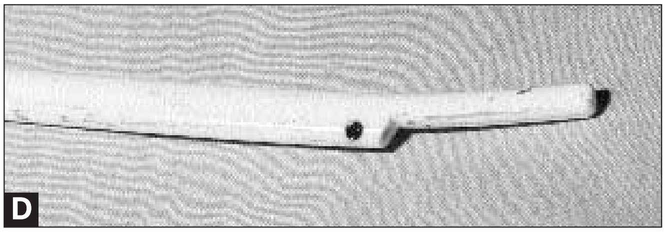

FIGURE 5-22 *(Continued)*

D, The clot is typical of one that is remarkably tenacious. Before replacement of this catheter, a variety of manipulations were performed, including attempted thrombolysis with localized infusion of urokinase. A new catheter was placed in the same site in a same-day procedure using local anesthesia.

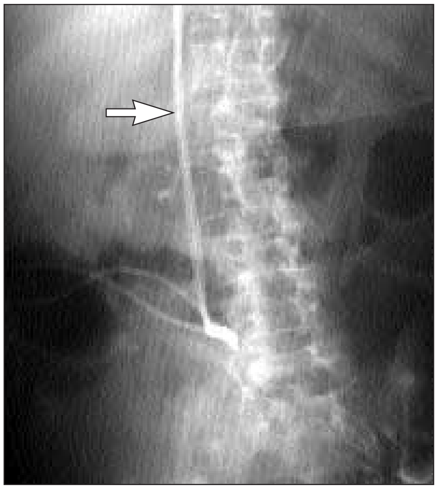

FIGURE 5-23

Translumbar catheter placement. Patients receiving chronic hemodialysis may exhaust potential sites for permanent vascular access. Additionally, after long-term use of central vein catheters, these sites also develop irreversible occlusion. In most cases, these patients are trained for peritoneal dialysis; however, some patients cannot tolerate this modality. This patient failed all attempts at arteriovenous and central vein access placement, including those involving the vessels of the lower extremity. Peritoneal dialysis was not possible owing to recurrent disabling pleural effusions. Translumbar placement of tunneled catheters (*arrow*) into the inferior vena cava can provide a long-term solution for the patient with no apparent remaining access sites.