Prosthetic arteriovenous grafts for hemodialysis

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ABSTRACT: Introduction: Prosthetic arteriovenous (AV) grafts are indicated in patients with failed AV fistula (AVF), exhausted superficial veins or unsuitable vessels. Increasing the proportion of prevalent hemodialysis (HD) patients using autogenous AVF should reduce the need for AV grafts and associated morbidity. This paper reviews the current role of prosthetic AV grafts in vascular access for HD.

Technical considerations: Prior to the insertion of a prosthetic AV graft, a comprehensive review of previous access procedures and full physical examination in addition to vessel mapping is required. Anastomotic technique should take into account the flow diffuser concept, graft geometry and an anastomotic angle of 15° in order to reduce the incidence of intimal hyperplasia.

Results: Many authors report 1 and 2-yr cumulative graft patency rates of 59-90% and 50-82%, respectively. The major drawbacks with synthetic grafts include: thrombosis, a five-fold increase in infection risk and steal syndrome. The choice between surgical and percutaneous methods of dealing with blocked AV grafts remains controversial, though percutaneous techniques are assuming an increasingly important role. Percutaneous strategies are successful in declotting access in 67-95% of cases. Stenting of stenotic lesions following thrombectomy improves secondary patency rates. Strategies for dealing with AV graft infection include antibiotic prophylaxis, partial, subtotal or total graft excision and the use of biological prosthesis.

Conclusions: Though more prone to complications than autogenous AVFs, AV grafts offer a short maturation period and are more amenable to thrombectomy by radiological or surgical means. Complex AV grafts may be appropriate in patients with exhausted access sites. (J Vasc Access 2009; 10: 137-47)

Key words: Prosthetic grafts, Polytetrafluoroethylene (PTFE), Cumulative patency, Thrombosis, Graft infection

INTRODUCTION

Recent trends in hemodialysis (HD) include an increase in elderly patients requiring dialysis, prevalence of diabetes mellitus, increasing proportion of long-term dialysis patients and use of high efficiency dialysis. This changing demography of the dialysis population has led to an increase in the proportion of patients requiring more complex vascular access modalities for long-term HD. Non-autogenous or prosthetic arteriovenous (AV) grafts are considered as secondary or tertiary access modalities because the operation is more demanding. These access modalities are associated with a greater morbidity than with the autogenous AV fistula (AVF). They also have inferior primary and secondary patency compared to autogenous AVFs (1-4). In spite of notable developments in vascular access methodology, access related morbidity remains the major impediment to full rehabilitation of the chronic HD patient (5). There is wide variation in the use of prosthetic AV grafts in different parts of the world - high in many parts of the USA (6) and low in Europe. To address this, the Fistula First Initiative Workgroup introduced 11 Change Concepts that have resulted in a significant increase in autogenous AVFs in the prevalent HD population between 2002 and 2006 (7). Continuous quality improvement schemes adopted by multidisciplinary teams are effective in increasing the proportion of established dialysis patients using autogenous fistulae (8, 9). However, early failure of fistulas due to thrombosis and/or inadequate maturation is a barrier to increasing the prevalence of autogenous fistulas in patients treated by HD (10). Dember et al (10) conducted a large multicenter trial involving 877 participants and reported failure of AVFs to attain suitability for dialysis in 460/758 patients (60.7%). This unusually high “failure to mature or become suitable rate” is probably a reflection of the stringent criteria used to define non suitability for dialysis. It is also conceivable that enthusiastic efforts by treating physicians at participating centers to increase AVFs might have resulted in liberalization of the selection criteria for fistula creation.

The indications for prosthetic AV grafts include: failed AVF/exhausted superficial veins (11); lack of suitable vessels particularly in elderly and diabetic patients; destroyed vessels by indiscriminate venipuncture; late referral for vascular access (12); need for immediate cannulation with avoidance of a central venous catheter (relative indica-
Graft materials

Prosthetic AV grafts are classified as either biological or synthetic. In general, biological prostheses are of limited availability, expensive and of variable size and quantity. Biological grafts include:

- Denatured homologous vein allograft.
- Cryopreserved saphenous vein - no evidence of immunologic activation in spite of not matching for blood group or human leucocyte antigens. (15) Caution should be exercised in patients at high risk for infection. Bolton et al (16) reported 11 graft infections in 20 patients, 6 who had associated graft rupture. One of these patients died from exsanguination.
- Bovine heterografts - typified by SynerGraft Vascular Graft Model 100 (SGVG 100), a decellularized non-chemically cross linked bovine ureter vascular graft which provides a safe alternative for patients with a history of multiple failed synthetic grafts (17-19).
- Human umbilical vein.
- Sheep collagen grafts.

The commonly used synthetic grafts include Dacron® (E.I. du Pont de Nemours and Company) and polytetrafluoroethylene (ePTFE) Gore-Tex; WL Gore and Associates, Inc, Flagstaff, AZ; Impra: BARD/Impra Inc, Tempe, AZ). The fibrillar structure of Dacron® was expected to encourage tissue ingrowth and provide greater durability for recurrent cannulation. However, this expectation was not seen in practice and PTFE, a fluorcarbon polymer became the prosthetic graft of choice (5, 20). Stretch expanded PTFE (ePTFE) is preferable to standard ePTFE. Tordoir et al (21) carried out a prospective comparison of stretch ePTFE vs. standard PTFE in 37 patients (17 stretch, 20 standard) and reported similar incidents of puncture complications in both groups, but a higher 1-yr cumulative patency rate in the stretch ePTFE group (59 vs. 29%; p<0.01). Available data supports PTFE over other biologic and synthetic materials based on a lower risk of disintegation with infection, low thrombogenicity, low tissue reactivity, prolonged patency and improved surgical handling (22-24). However, Procol® (Hancock, Jaffe, Laboratories, Irvine, CA), a bovine mesenteric vein graft which closely resembles the human saphenous vein is reported to have better survival than PTFE (25). Bacchini et al (25) compared the primary and secondary patency rates of Procol® to ePTFE and a second autogenous fistula. It was reported that over a period of 20 months, the Kaplan-Meier cumulative graft survival for the bioprosthesis was significantly higher than for ePTFE (82 vs. 50%; p<0.04).

Other new graft materials include polyurethane grafts with their self-sealing properties and reported low complication rates (26). The polyetherurethaneurea (Vectra graft) is suitable for early needling. With a median of 15.5 days from insertion to needling only 6/190 (3.2%) developed a bleeding complication (27).

Technical considerations

Preoperative evaluation: The first principle must be to perform the best and most appropriate vascular access, always aiming to create an autogenous AVF. The decision to insert a prosthetic AV graft must be preceded by a comprehensive review of previous access procedures and a full physical examination and vessel mapping using ultrasound color duplex. A protocol of non-invasive assessment increased the use of autogenous AVFs from 14% during 1992-1994 to 63% during 1994-1997 (28). In another prospective series, vessel mapping led to a change in the planned access procedure in 31% of patients (n=70), a rise in autogenous AVF rate from 42% to 58% and a fall in negative exploration rate (29). Vessel mapping has the potential of reducing the overall necessity for multiple access procedures and avoiding early use of secondary access procedures. Prior to inserting synthetic grafts, it is important to answer questions regarding the inflow (condition of the arterial tree) and the outflow (venous circulation - size, depth and flow properties through the vein). Silva et al (28) applied preoperative ultrasound examination of both the arterial inflow and the venous outflow and concluded that a minimal vein diameter of 4 mm was required for a successful PTFE-vein anastomosis. Malovrh (30) showed that conversion of a high resistance triphasic Doppler flow signal to a low resistance biphasic flow signal after the release of fist clenching resulted in a higher fistula patency rate.

Although insertion sites in the upper limb are preferred because of the lower risk of associated sepsis, when the upper limb sites are exhausted the thigh is the next favored site (31-33). Slater and Raftery (34) reported a cumulative graft patency of 80.5% at 2 yrs with no graft loss due to sepsis in a series of 22 thigh grafts inserted in 21 patients. However, Englesbe et al (35) reported a less favorable experience. Twenty-seven percent of the femoral
AV grafts were lost to sepsis with an overall secondary patency rate of 26% at 2 yrs. When implanted in the thigh, the graft can be either a straight, looped or curved configuration (Fig. 1). Inserting a thigh AV graft to the common femoral vessels in close proximity to the groin has the disadvantage of a higher infection risk and complications due to dissection through the dense lymphatic tissues. This has led to implantation of the AV graft more distal to the mid-superficial femoral vessels (36). This approach preserves the proximal vessels for future graft revision, as was the case in 4/38 of their cases.

Forearm grafts of loop configuration yielded greater overall patency rates and required fewer revisions than forearm grafts of straight configuration (37). Axillary loop grafts are indicated when more distal options for vascular access are exhausted or when the risk of steal syndrome is extremely high. Jean-Baptiste et al (38) reported a 1-yr primary patency of 51% and 18-month secondary patency of 80%. The commonly performed procedures include a straight graft from the radial artery at the wrist to a cubital fossa vein; a forearm loop graft between the brachial artery and a cubital fossa or basilic vein; brachio-axillary graft; axillo-axillary graft; and thigh graft between the common femoral artery and the femoral vein or the stump of the great saphenous vein (Fig. 2). More complex bypass AV grafts including a necklace graft between the left subclavian artery and the right subclavian vein or vice versa are reserved for patients with multiple access failures, exhaustion of usual sites and in whom peritoneal dialysis or transplantation is not feasible (39).

**Technique:** The operation can be performed under general or regional anesthesia. The main steps of any AV graft insertion include:
- Adequate exposure of the relevant artery and vein.
- Venous anastomosis usually established first.
- Counter incision for tunneling should not be located over the loop to avoid skin erosion by the graft (20).
- Tunneling device should have a smaller diameter than the AV graft diameter.
- The subcutaneous graft should be placed as superficial as possible.
- Bevelled anastomosis using 6/0 Prolene for both venous and arterial anastomosis.
- After the procedure, the pulsatility of the graft should be monitored with and without clamp occlusion of the outflow end of the graft.

Some authors advocate intravenous administration of 5000 units of heparin after tunneling the graft (20).

**Pathophysiology**

A newly placed PTFE AV graft requires a period of wound healing and incorporation of fibrous tissue before use; a period typically lasting 2-3 weeks. Flow increases

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**Fig. 1** - Anastomotic configuration of AV grafts in the right upper limb. 1: curved brachio-axillary; 2: looped axillo-axillary; 3: forearm looped brachio-basilic; and 4: straight radial to cubital fossa vein.

**Fig. 2** - Looped graft between the common femoral artery (CFA) and the stump of the great saphenous vein in the left thigh.
to a maximum in a few weeks. The absolute flow is limited by the diameter of the graft at its distal anastomosis or by the size of the draining vein. Stenosis predominantly occurs in the draining vein and results in a reciprocal drop in flow through the access. Serial measurements of intra access pressure or flow can provide an indication of the development of venous stenosis. AV grafts begin to thrombose at flow rates less than 600 ml/min - well above the level required for adequate dialysis (300 ml/min) (40). In a prospective randomized comparison of two grafts of different diameter - 6 mm straight vs. 8 mm tapered to 6 mm at the arterial site, placed in the upper limb for HD, Polo et al (41) demonstrated superior patency and lower complication rates with the larger diameter graft. Their results showed that the larger diameter graft produced a higher access flow rate (1397 vs. 975 ml/min) and better primary and secondary patency rates.

Most synthetic AV grafts can be used soon after insertion eliminating the need for temporary central venous catheters. Hakaim and Scott (42) compared the immediate and long-term outcome of 48 patients whose AV grafts were used for dialysis within 72 hr of surgery with 31 patients who underwent late cannulation (after day 14). All patients received stretch ePTFE grafts in the brachial arterial site to axillary vein configuration. Similar cumulative patencies and no cannulation hemorrhage or wound infection was seen in either group. For this reason, nephrologists often persuade their surgical colleagues to insert AV grafts instead of fistulas in patients who present for dialysis without a previously planned access.

Complications

The major drawbacks associated with synthetic grafts are stenosis with or without graft thrombosis, infection and vascular steal syndrome. Other complications include venous hypertension, pseudoaneurysm formation and neurological disorders. Median nerve neuropathy has been reported (43) and is thought to be due to post-operative limb swelling following AV graft insertion.

Thrombosis: Thrombosis is usually due to outflow tract obstruction in most cases although in about 20% no identifiable cause is found. Potential causes include dehydration, hypotension, compression during sleep and excessive pressure to stop hemorrhage post-venipuncture or dialysis.

Intimal hyperplasia is responsible for stenosis at the graft-vein anastomosis. Reasons proffered for intimal hyperplasia include: compliance mismatch between the vein and graft, boundary layer separation, enhanced particle residence time, increased low shear stress and high flow velocity of blood at the anastomosis (44, 45). Efforts at reducing the incidence of intimal hyperplasia have evolved from research into the following concepts: flow diffuser, graft geometry and anastomatic geometry.

In commercial oil and gas lines, diffusers are used to accommodate the mismatch between two dissimilar areas by interposing an approximately 16% enlargement at the point of insertion, to decrease the velocity and increase the pressure. When this concept was applied to femoral artery to femoral vein graft, the primary graft failure rate decreased from 47% to 12% (46). Fillinger (47) studied the effect of graft geometry and hemodynamics in a canine AV loop graft model of intimal medial hyperplasia using color Doppler imaging to demonstrate energy transfer out of the vessel in the form of perivascular tissue vibration. Non-tapered 6 mm diameter PTFE grafts were compared with 4 to 7 mm taper and 7 to 4 mm taper grafts over a 12-week period. Hyperplasia was significantly decreased in 4 to 7 mm taper grafts. Kinetic energy transfer (caused by flow disturbance) correlates strongly with the development of intimal hyperplasia. Fisher et al (48) demonstrated a beneficial effect of precuffed grafts on harnessing hemodynamic forces. In another animal experiment, Kisin et al (49) studied the effect of vein interposition cuffs on the development of intimal hyperplasia in response to PTFE bypass grafts. Intimal hyperplasia development was significantly lower in all areas of the anastomosis with vein interposition cuffs compared to standard end-to-side anastomosis or with cuffs constructed with PTFE. The high incidence of intimal hyperplasia with cuffed PTFE grafts despite a similar geometric configuration to vein interposition cuffs suggests that the biological properties of autogenous tissue dissipate intimal hyperplasia development. As the flow patterns in vein interposition cuffs are similar to cuffed PTFE grafts, it would suggest a less important role of hemodynamic forces in producing intimal hyperplasia.

The influence of the anastomotic angle upon hemodynamics has been investigated using a porcine aortic model with 8 mm polyurethane interposition grafts and an end-to-side configuration. Distal anastomoses were created with angles of either 90, 45 or 15°. Both the 90 and 45° anastomosis displayed a zone of recirculation at the anastomosis, while the 15° anastomosis displayed no flow disturbance (50).

To reduce the risk of PTFE graft thrombosis, some clinicians have used prophylactic anticoagulants or anti-platelet agents (low molecular weight heparins (LMWH), Warfarin, Aspirin, Dipyridamole or Clopidogrel). Clopidogrel, an inhibitor of adenosine diphosphate induced platelet aggregation, was shown in a pharmacodynamic study to be well tolerated by uremic patients on HD. Although its effect lasted 7 days after stopping the drug, there was no increase in the time required to achieve hemostasis after removing dialysis needles (51). Whether low dose Warfarin reduces the risk of failure of PTFE dialysis grafts was the subject of a multicenter, randomized, double blind, placebo-controlled trial. Warfarin was administered
to achieve an INR of 1.4-1.9 (52). While there was no significant difference in the time to graft failure between the two groups, there were six episodes of major hemorrhage in the Warfarin group compared to none in the placebo group. Surgical thrombectomy performed soon after graft thrombosis (53) and combined with either patch angioplasty to widen the outflow vein or a jump graft to bypass a stenotic area is required for a successful outcome and is considered by some authors to be the optimal choice for treating occluded AV grafts (54, 55). Two randomized trials comparing surgery vs. mechanical thrombectomy both showed superior success rates with surgery and revision (94% and 83%, respectively, compared to 67% and 72% for thrombolysis, respectively) (53, 54). Green et al (56) analyzed all available randomized controlled trials comparing surgical thrombectomy, mechanical thrombectomy and pharmacomechanical thrombolysis for thrombosed dialysis grafts and concluded that surgical thrombectomy gave superior results to other forms of treatment. Dialysis can be resumed immediately after surgical thrombectomy without the need for an interim dialysis catheter and the procedure is less painful and poses less risk of complications for the patient. Dougherty et al (55) reported their experience in treating 80 patients with clotted AV grafts over a 4-yr period. They found no difference in patency rates, but a substantially higher cost associated with thrombolysis treatment.

Surgical thrombectomy has recently been challenged as the primary treatment of thrombosed AV grafts by pharmacological thrombolysis with or without percutaneous balloon thrombectomy, clot maceration, suction thrombectomy or mechanical thrombectomy. The results of pharmacological thrombolysis are comparable to those of surgical thrombectomy (54, 55, 57, 58), but the former has the advantage that overnight hospitalization is not usually required. Pharmacological thrombolysis is usually performed using urokinase or recombinant tissue plasminogen activator (rt-PA), with increasing usage of a crossed catheter pulsed spray technique (59). This allows maximum exposure of the thrombus to the thrombolytic agent and can be combined with angioplasty of any associated stenotic lesion (55, 59). Percutaneous strategies are successful in de-clotting access in 67-95% of cases (53, 58, 60, 61) and when combined with aggressive endovascular management of subsequent thrombosis, the long-term secondary patency rates (62% and 47% 1 yr and 2 yrs, respectively) are significantly improved (62). Polak et al's retrospective review of their experience suggested pharmacological thrombolysis with angioplasty was superior to surgical thrombectomy alone, and equivalent to surgical thrombectomy/surgical revision (63). Post rt-PA thrombolysis angiography or Doppler studies in partially successful or unsuccessful cases will clarify anatomic stenosis and allow targeted radiological or surgical correction. The role of stenting of the venous anastomoses following thrombectomy in extending access life was studied by Maya and Allon (64). They compared 14 patients with thrombosed AV grafts treated by thrombectomy and stenting with 34 sex, age and date-matched controls treated by thrombectomy and angioplasty. The assisted or secondary patency (time from thrombectomy to permanent graft failure) was longer for the stent group (median survival 1215 vs. 46 days).

The choice between surgical and percutaneous methods of dealing with blocked AV grafts remains controversial, though percutaneous techniques are assuming an increasingly important role (65). Where the technology is available, pharmacomechanical thrombolysis with or without percutaneous transluminal angioplasty and stenting may present a slight advantage over surgical thrombectomy. Surgical salvage of a thrombosed AV graft after an unsuccessful percutaneous intervention is rarely feasible. Only 6/77 AV grafts undergoing unsuccessful percutaneous thrombectomy in Maya et al's series (66) could be revised surgically. Pharmacomechanical thrombolysis provides rapid, consistent and safe re-canalization of clotted AV grafts (59). However, patients who have anatomic problems that do not respond to treatment with catheter techniques, for example, stenosis unresponsive to percutaneous angioplasty, severe aneurysmal degeneration or local graft infection are candidates for new access surgery. Patients with significant risk for bleeding should not undergo thrombolysis. Local bleeding is common, but systemic complications are rare with rt-PA provided patients at risk of bleeding are excluded (61). Local bleeding is easily controlled by digital pressure and it is rarely necessary to stop the infusion.

**Infection:** PTFE usage compared to autogenous AVF is associated with a five-fold increase in access infection (67). A large prospective cohort study involving one-third of the Canadian HD population found a 19.7% probability of PTFE graft infection compared with 4.5% for autogenous AVF (68). However, in another large series of 1441 prosthetic AV graft procedures in a single center, only 51 (3.5%) AV graft infections in 45 patients were encountered (69). The risk factors for AV graft infections include diabetes mellitus, insertion in the thigh, history of multiple infections, number of surgical revisions, immunocompromised state, obesity and thrombosed, abandoned AV grafts (14, 69, 70-72).

Infection may present in the form of bacteremia, abscess around the graft, septic emboli, secondary hemorrhage and death. Infection is a common cause of graft loss (26, 35, 73). It accounts for about 35% of patients losing AV grafts in some series (74).

Efforts at reducing vascular access related infections should focus on increasing the placement of autogenous fistulae and minimizing the use of central venous catheter...
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ters. Prophylactic antibiotics are recommended to reduce the risk of intraoperative contamination of prosthetic AV grafts. However, the time course and bacteriology of most prosthetic AV graft infections suggest inoculation of skin flora due to poor needling techniques or seeding from distant sites such as intravenous catheters. *Staphylococcus aureus* infections occurred more frequently in carriers than non-carriers. In 90% of infected carriers, infection of the access site, skin or soft tissue was caused by the same phage type as that carried in the nares (75). Eradication of nasal carriage should result in a lower incidence of graft infection. Use of cryopreserved human femoral vein (Cr-and nasal carriage should result in a lower incidence of graft infection. Use of cryopreserved human femoral vein (Cr-yoLife, Inc Kenneson, GA USA) which has the ability to revascularize thereby enabling the patient to resist infection (76). Infected old clotted AV grafts should be excised without delay. Patients with recognized risk factors for infection should also have their thrombosed non-functioning AV grafts excised (72).

The critical issues in the management of AV graft infection are the need to eradicate infection and to achieve HD with reduced morbidity. Treatment involves intravenous antibiotics and graft excision (total, in septic patients or when graft bathed in pus; subtotal, when all of the graft was removed except an oversewn small cuff of prosthetic material on an underlying patent vessel; and partial, when a limited portion of AV graft is removed and a new graft inserted through adjacent sterile tissue) (69). A localized abscess around the graft may be amenable to limited excision and bypass of the infected segment (20, 77). Though necessitating the use of a central venous catheter, total or subtotal graft excision had a successful outcome in all cases, whereas partial graft excision was accompanied by graft patency and wound healing in only 74% (69). However, if infection occurs before the graft is embedded into the tissue the whole graft should be excised. Schanzer et al (78) have reported good short-term results following ligation of brachial artery in 21 patients with infection involving the graft-artery anastomosis in the upper limb. This method is particularly useful in critically ill patients with densely scarred wounds, but long-term results are required to ascertain whether patients ultimately manifest ischemic symptoms. Treatment of AV graft infection should therefore be optimized for the patient in question.

**Steal syndrome:** A less common, but more challenging, complication of AV grafts and AVF is symptomatic extremity ischemia caused by the diversion of arterial flow through the access site. The risk factors for steal (distal hypoperfusion ischemic syndrome) include female gender, age >60 yrs, diabetes mellitus, previous operations on the same limb and use of a brachial instead of radial artery (79). In a recent review of the subject, Malik et al (79) described three etiological entities for vascular access associated steal: arterial stenosis; high fistula flow; and lack of vascular adaptation or collateral flow. Patients may present immediately following AVF formation with cool, pale, numb, painful digits or months to years later with finger necrosis and/or permanent nerve damage. Steal syndrome, whether acute or late onset (>30 days), is more common in patients with extremity occlusive disease, particularly the elderly and diabetic. Unfortunately, there is no reliable method to predict who will develop steal syndrome after constructing an AVF or graft and ultrasound color duplex examination does not give accurate information about the microcirculation. The yield from segmental and digital pressure evaluation is too low to justify routine testing of all access patients (80). A small subset of patients develops dialysis treatment related ischemia. It is speculated that the blood pressure drop, which occurs during dialysis, severely reduces the perfusion pressure through the collateral blood supply in an already compromised vascular bed resulting in pain.

Vascular steal syndrome poses two problems: preservation of uninterrupted vascular access and resolution of distal ischemia. The complex interaction between the three factors mentioned above demands that each case of steal syndrome requires robust investigations in order to determine therapeutic choices. Various methods of managing steal syndrome have been tried including observation (mild cases but frequent follow-up required) access banding, ligation, angioplasty, bypass, sympathectomy, distal revascularization interval ligation (DRIL) procedure (80-83) and flow reduction with prospective Doppler ultrasonography guided surgery (84). Partial banding of the access conduit at its midpoint is an attractive method because of the benign nature of the procedure (85). The procedure is often accomplished under local anesthetic without sedation to allow immediate assessment of its effect. Banding is useful only for controlling flow through the access conduit. Ligation of the AVF or graft is the simplest and most effective procedure for relieving ischemic symptoms but leaves behind the need for a new access. DRIL presents an attractive alternative and Berman et al (80) achieved limb salvage and maintenance of access in 100% and 94% of patients (n=21). In a more recent report including 55 procedures in 52 patients, Knox et al (86) recorded substantial or complete relief of ischemic symptoms in 70% and healing of digital ischemic lesions in 75%. The DRIL technique, though complex to perform, addresses the twin problems caused by steal syndrome and should be the operation of choice in dealing with access related steal syndrome (87).

**Venous hypertension:** Limb swelling, hyperemia and pain after AV graft insertion usually signify hypertension within the venous system. When limb swelling occurs distal to the site of the prosthetic graft, it is often due to incompetent valves in the deep venous system. However, if swelling involves the whole of the upper limb, central vein
stenosis is the cause. A mild form of venous hypertension can be managed conservatively by limb elevation until sufficient central venous collaterals develop. Options for treating more severe forms include: percutaneous balloon angioplasty of the stenotic central vein with or without intravascular stenting, ring PTFE bypass (88) or ligation of the AV graft.

Pseudoaneurysm: Pseudoaneurysms have been reported in about 16% of thigh PTFE grafts (89). False aneurysms develop in response to repeated needling in the same segment of the AV graft and can be avoided by careful rotation of needling sites.

Outcome

Early outcome: Kidney Disease Outcome Quality Initiative (K-DOQI) recommends that the primary failure rate (failure within 30 days or before use for dialysis) should not be more than 15% for forearm straight grafts, 10% for forearm loop grafts and 5% for upper arm grafts (90). Primary failure of dialysis AV graft is often caused by technical problems influenced by surgical access construction, patient demographics, comorbidity and graft loss due to premature cannulation and hematoma formation (20, 37, 91, 92).

Long-term outcome: Many authors report 1- and 2-yr cumulative patency rates of 59-90% and 47-85%, respectively (11, 20, 21, 34, 37, 41, 62, 76, 91-96). AV grafts inserted into the thigh have lower 1- and 2-yr cumulative patency rates of 41-68% and 26-43%, respectively (35, 36). Thrombosis and or stenosis account for most causes of AV graft impairment or loss. Uncorrected stenosis is associated with eventual AV graft thrombosis. Access surveillance coupled with radiological or surgical intervention has been known to prolong access life (95, 97, 98). Cayco et al (99) introduced a vascular access surveillance protocol (using dynamic venous pressure >140 mmHg, recirculation >15%, graft limb swelling and prolonged bleeding post-dialysis) to decide who to refer for angiography with or without angioplasty and demonstrated a reduced thrombotic episode per graft year of 0.29 compared to 0.49 for a historical, controlled group in their center. AV grafts revised electively have a better survival than grafts revived at the time of thrombosis and are associated with a decreased number of clotting episodes per patient year (100).

Conclusion

The use of synthetic AV grafts for vascular access is associated with a number of advantages. AV grafts provide a large surface area for cannulation and are technically easier to needle (12, 101). They are available in various shapes and sizes to facilitate placement (12, 20, 91). Furthermore, AV grafts offer a shorter maturation period and are more amenable to thrombectomy by radiological or surgical means than autogenous AV access. The main disadvantages include the development of graft stenosis particularly at the graft venous anastomosis, bleeding from puncture holes, tendency to kinking of the graft and stiffness of the material which may cause technical difficulties. They are generally associated with a poorer long-term patency, higher levels of complications and require more interventions than autogenous AVF. Excessive use of PTFE grafts is associated with a high morbidity in dialysis patients.

There is an increasing subset of patients in whom AVF or prosthetic AV grafts cannot be created or maintained owing to age, comorbid diseases such as diabetes, cardiac or peripheral vascular disease or multiple previous failed accesses. For such patients consideration should be given to more complex AV graft bypasses or fistulae (39).

Disclaimers: None.

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