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EDUCATIONAL ARTICLE

Primary Vascular Access

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Primary vascular access is usually achievable by a distal autogenous arterio-venous fistula (AVF). This article describes the approach to vascular access planning, the usual surgical options and the factors affecting patency.

Keywords: Vascular access; Haemodialysis; Arteriovenous Fistula; Risk factors.

Introduction

Whilst many patients with end stage renal failure obtain renal replacement therapy by peritoneal dialysis or renal transplantation, almost all will require a period of haemodialysis and most will be maintained on this modality over a long period. To achieve successful and reliable haemodialysis easy access to the circulation is required which provides a blood flow through the dialysis machine in excess of 2–300 ml/min. Temporary access is required for patients presenting acutely with renal failure whilst awaiting placement and maturation of a permanent access but in about two thirds of patients the need for renal replacement therapy can be anticipated, allowing permanent vascular access to be created in advance.

Temporary Access

In the 1960s haemodialysis was performed via external arterio-venous shunts[1] but these were uncomfortable for the patient, had the potential for sudden disconnection with severe haemorrhage, and frequently underwent thrombosis or infection.[2] The autogenous AV fistula, first described in 1966,[3] proved to have great advantages for permanent access but Scribner shunts continued to be used for emergency access. The double lumen central venous catheter, introduced in 1980,[4] rapidly superseded the Scribner shunt for emergency access, providing reliable access with good flows and could be maintained for weeks or months, especially if a Dacron cuff was incorporated in a subcutaneous tunnel to act as a barrier to infection.[5] Despite modifications, central venous catheters have proved unsuitable for long-term use, except in patients with a short life expectancy or in whom other opportunities for access have been exhausted, because of their increased rates of bacteraemia, repeated episodes of thrombosis and the risk of central venous stenosis or thrombosis.[6]

Permanent Vascular Access for Haemodialysis

Vascular access planning

- Permanent access is best provided by an autogenous arterio-venous fistula (AVF), although in the absence of adequate superficial veins a prosthetic AV bridge graft may be used.[7,8] In most European series over 90% of patients receive an autogenous AVF and it has been suggested that at least 80% of prevalent patients should dialyse via an autogenous fistula and 66% of new patients should start dialysis with an AVF.[9]

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- Access placement should make the maximum use of available sites, starting as distally as possible, to allow the construction of a more proximal fistula in the event of failure. The non-dominant arm is preferred to allow tasks such as writing during dialysis and self-needling if home dialysis is anticipated.
- When access sites on the non-dominant arm are unavailable, the dominant arm and, as a last resort, the leg can be used.
- There is increasing evidence that preoperative duplex scanning improves the selection of the level of a fistula, reduces the failure rate[10] and increases the number of autogenous fistulae in units with high prosthetic graft usage.[11] It is particularly helpful in obese patients where preoperative scanning ensures a similar rate of formation of a functioning AV fistula.[12]

The radiocephalic AV fistula

For long-term access the radiocephalic AVF at the wrist has proved the gold standard over many years.[3] The operation is straightforward and is easily accomplished under local anaesthetic. The cephalic vein is mobilised to reach the radial artery, which lies just medial to the brachioradialis tendon at the wrist (Fig. 1). In most patients it provides an excellent blood flow along the cephalic vein, which usually lies superficially over a long length of the forearm. This allows easy cannulation by two widely separated needles so that recirculation is rarely a problem, except in failing fistulae, and gives efficient dialysis as measured by K_t/V. In obese patients where the cephalic vein is located too deeply for easy cannulation it can be transposed into a more superficial position.[13] The results are generally good with a 15% primary failure rate[14], 1-year patencies of 70–85% and 5-year patency of about 50%.[15,16] Complications such as needle site infections or haemorrhage are rare. In the long term, venous aneurysms are common but rupture is rare so that most can safely be observed. Occasionally, sudden enlargement occurs, but threatened haemorrhage may be averted by timely fistula ligation or revision. Steal syndromes are similarly uncommon, occurring in $<2\%$.[17]

The initial report described a side-to-side anastomosis[3] but an end-to-side anastomosis between the vein and artery is now usually preferred as mobilisation of the vein is easier. The distal flow into the hand from a side-to-side fistula rarely has any clinical significance and occasionally causes troublesome

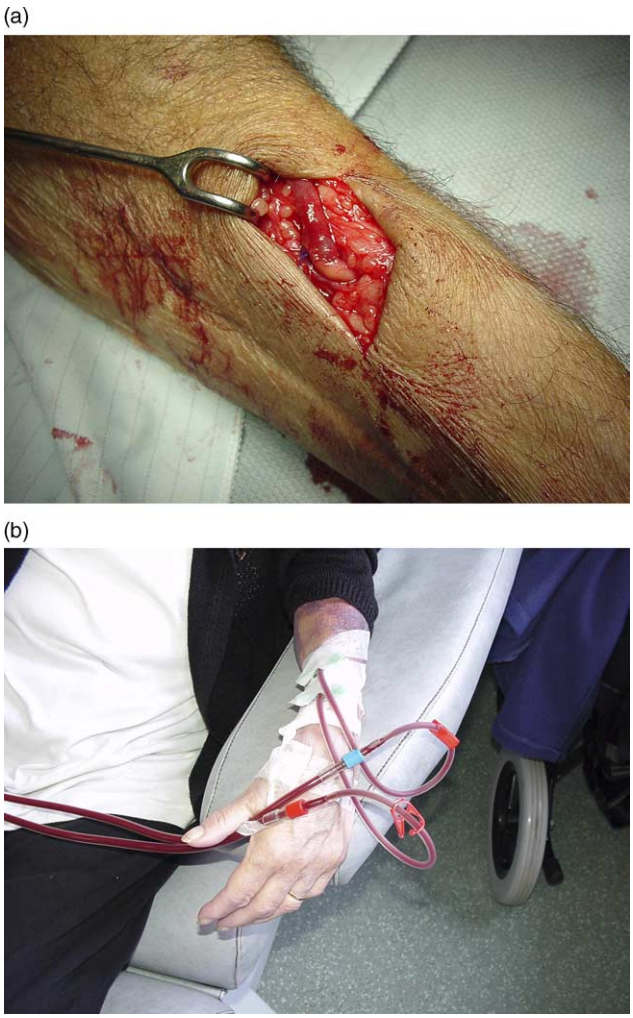

Fig. 1. The radiocephalic fistula at the wrist. (a) Completed fistula before skin closure. (b) Needle positions for dialysis.

venous hypertension with ulceration of the thumb. The direction of flow in the distal radial artery is reversed in about three quarters of patients with a variable contribution of the blood flow from the palmar arch.[18] This causes a reduced blood pressure in the thumb in most cases but this is rarely significant clinically[19] but if the inflow to the arch via the ulnar artery is deficient a steal syndrome may result, with ischaemia of the thumb and index finger. An end-to-end anastomosis between the proximal radial artery and the cephalic vein with ligation of the distal radial artery avoids this and is performed routinely in some units.[20] Nevertheless the end-to-side configuration remains more popular as fistula thrombosis usually leaves the radial artery in continuity to contribute to perfusion of the hand and the rare cases of steal usually respond to distal radial artery ligation beyond the fistula.[19,21]

(a)

Fig. 2. The snuffbox AV fistula. (a) Completed fistula before skin closure. (b) Needle positions for dialysis.

The snuffbox AV fistula

A radiocephalic AVF in the anatomical snuffbox (Fig. 2) is an excellent option in most patients and is the author's preferred first access.[22] The radial artery lies deep to the extensor retinaculum as it passes across the snuffbox, which it enters beneath the tendons of extensor pollicis brevis and abductor pollicis longus and exits between the heads of the first dorsal interosseus muscle. Whilst the vessels are slightly smaller and the artery is deeper with more branches to divide for mobilisation than at the wrist, the cephalic vein lies immediately superficial to the artery and requires little mobilisation. This fistula gives an extra few centimetres of vein for needle insertion and following thrombosis a wrist fistula can be constructed in about 45% of patients. In women the veins are usually smaller and the patency of AVFs is poorer than in men, so they more often require a more proximal fistula.

Forearm radiocephalic AV fistulae

The popularity of the distal cephalic vein for intravenous infusion in hospitals often leads to its thrombosis or phlebitis. Where thrombosis remains distal and the radial artery is adequate a more proximal radiocephalic AVF can be performed in the forearm. Here the radial artery lies deep to brachioradialis, which must be partially divided to give adequate exposure.

The ulnobasilic AV fistula

The basilic vein is usually of good calibre and is rarely used for intravenous cannulation leaving it available for fistula creation in most patients.[23,24] The ulnar artery is found between the tendons of flexor carpi ulnaris and flexor digitorum superficialis at the wrist where it lies medial to the ulnar nerve on flexor digitorum profundus and the basilic vein can be easily mobilised for anastomosis to it (Fig. 3). However, it is less popular because cannulation of the basilic vein is

(a)

(b)

Fig. 3. The ulnobasilic AV fistula. (a) Completed fistula before skin closure. (b) Needle positions for dialysis.

more difficult and patency may be compromised by pressure on the basilic vein when the forearm rests on a table or the arm of a chair.

Other autogenous forearm AV fistulae

Whereas options for primary access usually depend upon venous availability, elderly patients with renal failure are frequently subject to atheromatous or calcific arterial disease affecting the upper limb, which may limit options for fistula formation. In some cases, a patent basilic vein may be mobilised subcutaneously across the anterior surface of the forearm to form a radiobasilic fistula and conversely an ulnocephalic fistula may occasionally be the most distal option.

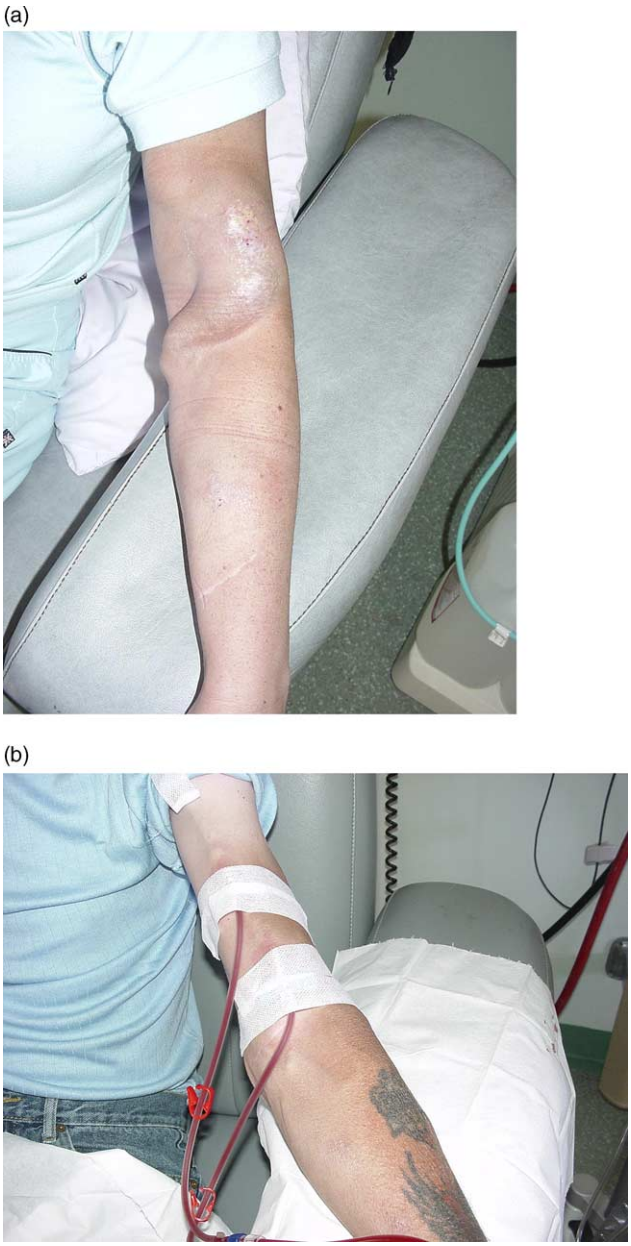

Fig. 4. The brachiocephalic AV fistula. (a) Aneurysmal fistula. (b) Needle positions for dialysis.

Brachial AV fistulae

The considerable variability of venous anatomy in the antecubital fossa allows a variety of possible configurations for brachial fistulae (Fig. 4). An end-to-side anastomosis of the median cephalic vein brachiocephalic AV fistula in the antecubital fossa gives excellent access to the circulation via needles in the upper arm cephalic vein. Reported patencies are excellent, and higher blood flows result but the incidence of steal is greater.[25] Higher flows can be achieved when both the median cephalic and median basilic (median cubital) veins are included in the outflow and this may accomplish maturation of the basilic vein for a possible later basilic vein transposition fistula the potential for steal is increased. The deep perforating vein can also be anastomosed end to side to the brachial artery,[26] which allows flow up both the cephalic and basilic veins but the smaller anastomosis may reduce the risk of steal without affecting patency.[27] Distal flow into a patent cephalic vein can sometimes be achieved by valve disruption.

Other options

Whilst in the vast majority of cases an upper limb autogenous fistula is possible there are a few patients in whom no suitable subcutaneous veins exist and primary access must be accomplished by a prosthetic graft, basilic vein transposition or even a lower limb fistula. These will be described in subsequent articles.

Factors Affecting Fistula Patency

Vessel size

Small arteries and veins have higher initial failure rates, more frequent failure to mature and poorer long-term patency.[28] It has been suggested that a cut-off of 2 mm for both the arterial and venous diameters should be used.

Fistula flow rates

The flow rate AV fistulae the day after surgery correlates inversely with the risk of thrombosis

although intraoperative flow rates are less reliable.[28] The hyperaemic response of brachial artery blood flow is a strong predictor of access patency and maturation, presumably by detecting proximal arterial stenoses.[29]

Access surveillance

The use of postoperative surveillance and pre-emptive repair of detected defects has been shown to improve access survival in a randomised controlled trial.[30]

Prior temporary access

Patients presenting acutely with renal failure have poorer AVF patency, which may be linked to the need for temporary access via a central venous catheter.[31]

Anastomotic method

Anastomosis using non-penetrating vascular clips, which give an interrupted anastomosis with excellent endothelial apposition and less bleeding, are quicker and may have improved patencies.[32,33]

Access position

More proximal AV fistulae have improved blood flow[34] and patency[35] but leave fewer options for access in the event of failure.

Early cannulation

This is not a risk factor for fistula thrombosis.[36]

Prosthetic AV grafts

Prosthetic AV grafts have poorer primary patency, require more revisions and have higher infection rates than autogenous AVFs.[37–39] However, their patency can be improved by using a wider diameter graft[40] or adding a vein cuff to the venous anastomosis.[41]

Gender

The patency of distal forearm, wrist or snuffbox AVFs is poorer in women than in men.[22,31,35,42] Since, this seems to apply also to more proximal AVFs it may be unrelated to the larger vessels of men and may have a hormonal basis.

Diabetes

There is conflicting evidence as to whether diabetes is an adverse factor for fistula patency with some authors suggesting that flow rates[34] and patency are poorer[35] whereas others have found no effect.[22,43,44]

Age

Increasing age has no effect on fistula patency.[22,45]

Obesity

It is more difficult to create a suitable AV fistula in obese patients because the deeper veins are more difficult to cannulate but this does not affect patency.[34]

Smoking

Smokers may have poorer fistula survival.[46]

Drugs

Antiplatelet agents such as aspirin and dipyridamole prolong fistula survival and are used routinely[47–49] although a combination of aspirin and clopidogrel increased haemorrhagic complications without influencing patency in prosthetic AV grafts.[50] Anticoagulation with warfarin reduces AVF thrombosis in patients with hypercoagulable states[51] but routine use is best avoided because of the risk of haemorrhage.[52] Surprisingly, warfarin was associated with poorer patency in the DOPPS study but this may reflect its use in patients with a history of fistula thrombosis or known thrombotic disorders.[49] Calcium channel blockers are associated with improved primary patency.[49] ACE inhibitors were found to have no effect on primary access patency in one study[53] but were associated with improved secondary patency in the DOPPS study.[49] Fish oil reduced the primary rate of AV fistula thrombosis in one randomised trial.[54] Erythropoeitin does not reduce[55] and, surprisingly, may improve patency, at least of AV grafts.[56]

Thrombotic tendencies and vasculitis

Increased fibrinogen predisposes to access thrombosis and vasculitis is a strong predictor of access failure.[57]

Surgical expertise

There can be little doubt that experienced surgeons with adequate training have good outcomes[35] but

well-supervised trainees can produce equivalent results.[58]

Management of the AV Fistula

It is essential to avoid unnecessary venepuncture and intravenous infusions in forearm and antecubital veins (especially the cephalic) both before and after AVF formation. External compression by tight clothing, bracelets or wristwatches should also be avoided. Cannulation is usually delayed for 6 weeks to allow maturation and should be performed by experienced nursing staff with strict asepsis. There are various needling possible strategies but area puncture is usually best for autogenous fistulae as it results in localised venous dilatation at preferred sites, which facilitates subsequent cannulation.[59] There is now good evidence that fistula surveillance by flow rate monitoring or by duplex scanning improves outcome. Thrombosis of autogenous fistulae or failure to mature is usually best treated by surgical revision or construction of a new AV fistula at a higher level although thrombolysis and angioplasty may have a place.

Conclusions

- Primary access is best provided by a distal autogenous AV fistula in the nondominant arm.
- For proximal AV fistulae may be required in patients with poor veins.
- Preoperative duplex scanning facilitates planning.
- Patency is improved by antiplatelet agents, fish oil and calcium channel blockers.
- Patency is worse in patients who present as an emergency, in women, smokers and in the presence of athrombotic tendency or vasculitis.

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