Surgery for renal replacement therapy

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Abstract

Surgical intervention is required for long-term access for both haemodialysis and peritoneal dialysis. As the number and complexity of patients on dialysis increases, this presents an increasing challenge. Successful renal access surgery requires both careful planning and technical skill. This article describes the evaluation of patients for surgery, explores the surgical options for both dialysis modalities and discusses the common complications of these.

Keywords Access; arteriovenous fistula; haemodialysis; peritoneal dialysis

Introduction

The two forms of dialysis available to patients with end-stage renal failure (ESRF) are haemodialysis and peritoneal dialysis. Access for both modalities requires surgical intervention. Traditionally this workload has fallen under the remit of the transplant surgery team, but in recent years vascular surgeons and interventional radiologists have become increasingly involved.

Access for haemodialysis

The gold standard access for haemodialysis is an autogenous arteriovenous fistula (AVF). However, patients may present acutely with ESRF requiring haemodialysis before an AVF has been formed. Additionally, as patients requiring vascular access become progressively older with more comorbidities and atherosclerosis, establishing an AVF becomes increasingly challenging. In these situations other approaches are necessary.

Temporary vascular access catheters

About 40% of patients with ESRF present acutely and require temporary vascular access for haemodialysis. This is achieved by percutaneous insertion of a double lumen large bore venous catheter. Other indications for the use of vascular access catheters are as follows;

- whilst waiting for maturation of autogenous AVF
- until an arteriovenous graft or peritoneal catheter is ready to use
- whilst waiting for upcoming planned living donor renal transplantation
- after previous failed vascular access or peritoneal dialysis
- permanent access once all other options exhausted.

The vein of choice for vascular access catheters is the right internal jugular vein. This provides the most direct route to the superior vena cava and right atrium and has greater patency rates than other sites.[1] Subclavian venous catheters should be avoided as they are complicated by stenosis in 40–50% of patients;[1] this complicates future AVF formation in that arm due to the risk of venous hypertension. If the internal jugular veins are not suitable for use, the femoral vein should be used as an alternative.

For short-term haemodialysis whilst an in-patient, non-cuffed, non-tunnelled catheters are acceptable. However, for long-term use these catheters have unacceptably high rates of catheter-associated bacteraemia. Therefore, they should be exchanged for a cuffed, tunnelled catheter. These were traditionally inserted by surgeons in theatre using an open cutdown method: the internal jugular vein is easily accessed through a transverse incision centred over the lower third of sternocleidomastoid. Latterly these have increasingly been inserted by nephrologists or radiologists using a percutaneous Seldinger technique. The use of ultrasound guidance in this situation increases first-time cannulation rates, decreases inadvertent puncture of the carotid artery and is recommended by NICE. Whichever technique is used, the catheter position should be checked radiologically to ensure its tip lies in the SVC.

The long-term use of vascular access catheters should be avoided, as the risk of thrombosis is high. However in some patients, particularly those who have been on haemodialysis for many years, all potential options for vascular or peritoneal access have been exhausted and this is the only option available.

Complications of vascular access catheters: as mentioned above, the principal complication of vascular access catheters is thrombosis. This occurs in around 15% of patients[2] and accounts for most catheter dysfunction. Treatment in the first instance involves infusion of a thrombolytic, such as urokinase, through the catheter. If this fails the catheter may need to be replaced, which can be done by exchange over a guidewire placed through the non-functioning catheter. In patients with recurrent catheter dysfunction long-term anticoagulation may be of benefit.

Other causes of catheter dysfunction include initial malposition or kinking of the tip, fibrin sheath formation around the catheter or central venous thrombosis. If in doubt injection of radio-opaque dye through the catheter under X-ray screening may help differentiate between these causes.

Catheter-related infection also results in failure of a significant number of vascular access catheters, with rates around two per 1000 catheter days for tunnelled lines.[2] Infection occurs most commonly by migration of skin organisms from the exit along the catheter track or via the lumen from contamination during handling of the catheter. Preventative measures include strict personal hygiene and handling of the catheter only by appropriately trained personnel. In most cases, exit site infections settle with oral antibiotics. Intravenous antibiotics should be instigated if there is evidence of systemic sepsis or bacteraemia on blood cultures. If the infection fails to resolve, catheter removal is necessary.

Arteriovenous fistulae and grafts

An autogenous arteriovenous fistula, where a peripheral vein is anastomosed directly to an artery, is the vascular access of choice for long-term haemodialysis. The ideal AVF for haemodialysis has the following characteristics.

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- blood flow greater than or equal to 300 ml/min
- sufficient length of vein to allow two needles to be inserted
- large diameter for easy venepuncture
- good long-term patency.

If it is to be successful, vascular access surgery needs careful planning and to proceed in a step-wise fashion. There are some general rules which should be adhered to:

- use the most distal suitable vein first
- use the non-dominant arm first
- arm vessels should be used in preference to leg vessels
- prosthetic grafts should only be used if no autogenous veins are suitable.

All vascular access surgery adheres to the basic principles of vascular anastomosis. The anastomosis is performed using a continuous, monofilament, non-absorbable suture. The edges of the vessels should be everted to exclude thrombogenic adventitia, there must be no tension and all layers of the vessel wall should be included in the suture to prevent subintimal flap formation. The success of surgery is indicated by the presence of a palpable thrill and audible bruit in the venous limb of the AVF.

The venous limb of an autogenous AVF matures and becomes arterialized over several weeks. This involves venous dilatation and thickening of the vessel wall. It is common to leave all AVFs for 6 weeks prior to needling, as early puncture can result in haematoma and early thrombosis.

Preoperative assessment: when deciding on the site of AVF formation the above general rules should be adhered to. In addition, an AVF is only going to be successful if the following requirements are satisfied:

- satisfactory arterial inflow
- patent superficial vein of adequate diameter
- no outflow obstruction (patent axillary, subclavian and central veins).

The arterial inflow is assessed clinically, with an easily palpable pulse usually being sufficient. Overt atherosclerosis can also be detected, although this does not necessarily preclude AVF formation at this site. Allen's test should be performed prior to radiocephalic AVF formation to confirm a patent ulnar artery.

The suitability of veins can be assessed either clinically or radiologically. A sound knowledge of the venous anatomy of the arm is paramount (Figure 1). Clinical assessment is performed by inspection and palpation following tourniquet placement around the upper arm. The patency of the cephalic vein in the forearm can be assessed by light percussion at the wrist, whilst feeling for a transmitted wave in the vein at the elbow. Ultrasound mapping may identify suitable veins not detected clinically, particularly in obese patients. The other option if no suitable arm veins are palpable is venography, where contrast is injected into a superficial vein in the hand or wrist and the venous anatomy of the arm demonstrated.

Assessment of the patency of the central venous drainage of the arm can also be performed by venography, duplex ultrasound or magnetic resonance venogram. Clinical signs suggesting central venous occlusion include prominent collateral veins around the shoulder, chest or neck with associated arm or neck swelling. Presence of these features necessitates assessment of the central veins.

Radiocephalic arteriovenous fistula: this is the first choice of AVF and involves anastomosis between the radial artery and cephalic vein at the wrist (Figure 2), which can be performed under local anaesthetic as a day case. It was first described by Brescia et al. in 1966, as a side-to-side anastomosis.[3] Many surgeons now prefer an end of vein-to-side of artery anastomosis as there is a lower incidence of venous hypertension in the hand. However, this can be avoided by ligating the redundant distal venous limb of a side-to-side anastomosis. Radiocephalic AVFs have a primary patency rate (without intervention) of around 63% at 1 year.[4]

Brachiocephalic arteriovenous fistula: in patients with either failed wrist fistulae in both arms or unsuitable forearm veins, the next step should be a brachiocephalic AVF. This involves an anastomosis between the brachial artery and cephalic vein at the elbow. It can also be performed under local anaesthetic as a day case. The disadvantage of a brachiocephalic AVF is the relatively short length of vein suitable for needling.

The anastomosis is most commonly performed as an end of vein-to-side of artery. Several variations are possible depending on the vascular anatomy at the elbow, which is variable. The median cubital vein, if present, may be anastomosed directly to the brachial artery. This has the advantage of arterializing both the cephalic and basilic venous systems.

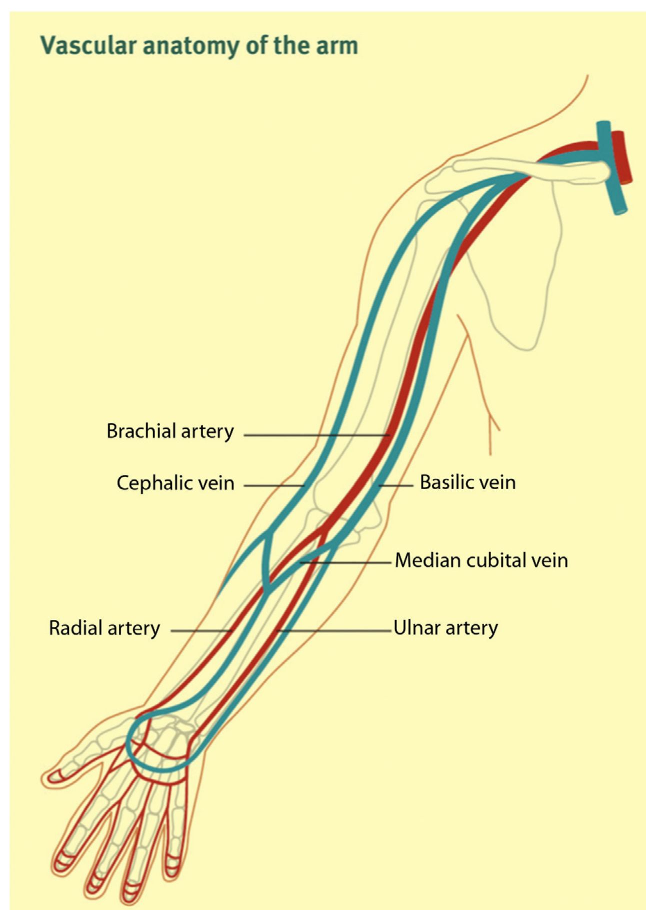

Figure 1