

Chapter 1

Vascular access in clinical practice

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Introduction

Access to the circulation is vital in many branches of medicine. In most cases a temporary route of access for delivering fluids or drugs to the venous system is all that is required. In other cases small quantities of venous or arterial blood must be withdrawn intermittently for haematological or biochemical analysis. Simple intravenous or arterial catheters are sufficient to accomplish these tasks. More specialised intravenous catheters introduced into the central veins are required for long-term intravenous feeding or for the administration of cytotoxic chemotherapy. By contrast, haemodialysis or haemofiltration requires the reliable withdrawal and return of blood to the circulation at high flow rates (preferably exceeding 300ml/min) on a regular basis.

The Scribner shunt was the first vascular access device used to allow circulation of blood from the arterial system through a dialyser to the venous system. This was used for several years but proved unreliable for long-term access because of repeated thrombosis and infection. It was also unpopular with patients because of its cumbersome extracorporeal tubing. The arteriovenous (AV) fistula, first introduced by Brescia and Cimino in 1966, involves the conversion of an accessible peripheral vein, usually in the upper limb, to a high flow vessel from which blood can be rapidly withdrawn and returned to the circulation via two needles introduced for each dialysis session. This dispensed with the need for extracorporeal tubing between dialyses and allowed greater freedom for patients undergoing chronic renal replacement therapy. However, the need for a period of maturation generally precludes the use of AV fistulae for acute dialysis. In the absence of a suitable superficial vein, prosthetic

grafts run subcutaneously from an artery to a vein can be used, but they are usually reserved for secondary access because of poorer patency and greater infection rates.

The introduction of dual-lumen central venous catheters supplanted the Scribner shunt for emergency and short-term use. More recent modifications have included the incorporation of a Dacron cuff around the catheters, which enables long-term fixation in a subcutaneous tunnel and acts as a barrier to infection. Single-lumen catheters with a Dacron cuff have also proved useful for long-term intravenous feeding and drug administration.

Whilst the vast majority of vascular access procedures are performed for haemodialysis, the access surgeon may occasionally be called upon to create an AV fistula for patients requiring plasmapheresis, to insert a long-term catheter for intravenous feeding or implant an injection port for the infusion of chemotherapeutic agents.

Renal replacement therapy

Haemodialysis is the most prevalent mode of chronic renal replacement therapy and is now almost universally used for acute dialysis. Peritoneal dialysis is an effective alternative mode of therapy, which allows greater independence for some patients. Unfortunately, the effectiveness of peritoneal dialysis tends to reduce after several years because of changes that occur in the peritoneal membrane. Renal transplantation is the preferred mode of treatment for most patients as it allows a near normal lifestyle, albeit at the expense of long-term immunosuppression, but many patients will return to dialysis after irreversible acute or chronic rejection. Thus, patients with end-stage renal failure will often move from one modality of treatment to another.

When is dialysis needed?

Acute renal failure

Temporary or permanent haemodialysis via a central venous catheter is required when the kidneys fail acutely, regardless of the underlying cause.

In some patients with acute renal failure, dialysis may be deferred or avoided by careful fluid restriction, and the control of acidosis and hyperkalaemia using intravenous bicarbonate, salbutamol or insulin and glucose combined with enteral resonium. When there is anuria or severe oliguria with fluid overload, gross metabolic acidosis, hyperkalaemia and a rising serum creatinine, acute haemodialysis via a central line will be required as a matter of urgency. In some patients, particularly those with fluid overload, for instance patients with multi-organ failure in the intensive care unit, continuous techniques involving haemofiltration and/or dialysis can be performed through a double-lumen central venous catheter.

In those patients with a treatable or spontaneously recoverable renal failure, dialysis may be discontinued as urine flow returns and serum biochemistry stabilises, but some will progress to require long-term renal replacement therapy. Once it is clear that renal recovery is unlikely, permanent vascular or peritoneal access should be created as soon as possible to minimise the use of central venous lines with their attendant increased risks of systemic infection and thrombosis. Central venous catheters are associated with a relative mortality risk of 1.7 in non-diabetics and 1.54 in diabetics in comparison to autogenous AV fistulae ¹. In the US, the National Kidney Foundation - Dialysis Outcomes Quality Initiative (NKF-DOQI) guidelines recommend that less than 10% of patients should be dialysed on lines beyond three months ².

Chronic renal failure

A third of patients with chronic end-stage renal failure present acutely or are referred within three months of the need for dialysis. Two thirds have progressive renal disease presenting with symptoms of malaise over a period of time or are discovered by routine biochemical tests during the investigation of hypertension, proteinuria or other medical problems. It is recommended by the UK Renal Association that patients should be referred to a nephrologist when the serum creatinine is 150-200 $\mu\text{mol/l}$ ³. The serum biochemistry and especially the creatinine clearance of such patients can then be monitored as an outpatient so that the need for dialysis may be anticipated. The actual start of dialysis may be primarily dependent on symptoms (e.g. malaise, nausea, anorexia, weight loss,

itching), but is sometimes precipitated by an acute deterioration in biochemistry during intercurrent illness or by dehydration.

Nevertheless, dialysis is usually required at a plasma creatinine of 500-1500 μ mol/l or when the creatinine clearance falls much below 14ml/minute. Plotting biochemical indices of renal function, such as creatinine clearance, for each patient may give an approximate date at which dialysis is likely to be necessary (see Chapter 2). When the start of dialysis can be anticipated, permanent vascular access should be created well in advance to allow for maturation of an AV fistula or for further procedures in the event of failure of the initial access. Peritoneal dialysis catheters should be inserted between 2-4 weeks from the anticipated date of onset of dialysis.

Guidelines for vascular access timing

In the US, the NKF-DOQI guidelines recommend ²:

- ◆ permanent vascular access should be constructed one year in advance of the anticipated need for dialysis, when the creatinine clearance falls below 25ml/minute or the serum creatinine rises above 4mg/dl (400 μ mol/l);
- ◆ a new primary AV fistula should be allowed to mature for at least one month and preferably 3-4 months prior to cannulation;
- ◆ dialysis AV grafts should be placed at least 3-6 weeks prior to an anticipated need for haemodialysis in patients who are not suitable candidates for primary AV fistulae;
- ◆ haemodialysis catheters should not be inserted until haemodialysis is needed.

The Vascular Access Society recommendations ⁴ are similar, stating that the anticipated mode of dialysis should be decided upon when the GFR reaches 20-25ml/minute and that an experienced access surgeon should see the patient when the GFR is 10-15ml/minute so that suitable access can be created 6-12 months in advance of dialysis. They also emphasise the need to preserve the forearm and upper arm veins on both sides for future access, avoiding venepuncture and cannulation at these sites.

In the UK the Renal Association ³ and the Joint Working Party of the Renal Association, The Vascular Society of Great Britain and Ireland and the British Society of Interventional Radiology ⁵ have produced the following service standards:

- ◆ at least 67% of patients presenting within three months of dialysis should start haemodialysis with a usable native AV fistula;
- ◆ at least 80% of prevalent haemodialysis patients should be dialysed using a native AV fistula;
- ◆ no patient already requiring dialysis should wait more than four weeks for fistula construction including those who present late;
- ◆ permanent vascular access should be created if possible at least 16 weeks and preferably six months before the anticipated need for dialysis.

Unfortunately, current practice in the UK often falls short of these standards. Whereas elsewhere in Europe, especially France and Germany, patients may receive their permanent access rapidly and efficiently, at present the under-provision of vascular access services in the UK mean that at least 50% of patients start dialysis with a central line (68% in the 2005 UK Renal Registry Report) in comparison with the European average of 33% ⁶⁻⁸. This also accounts for the high prevalence of patients dialysing on central lines in the UK (31%) ⁶. The Dialysis Outcomes and Practice Patterns Study (DOPPS) has shown that 58% of British patients have to wait more than three months for their first access after referral in comparison with 5% in Germany and France. Delays occur at all stages of referral, so that as many as 50% of those patients known to nephrologists more than 12 months beforehand start dialysis on a central venous catheter ⁶.

Conclusions

Patients with renal failure should, wherever possible, be referred early to a nephrologist so that permanent access can be constructed in advance of the need for dialysis to minimise the use of central venous lines. Where patients present in acute renal failure, dialysis must begin with a central venous catheter. However, there should be early provision of permanent vascular access in the form of an AV fistula or peritoneal access as soon as renal function is deemed irreversible.