The renal replacement therapy (RRT) dependent population in the UK is expanding at 5% per annum, currently representing 47,525 patients. While in part this cohort’s therapeutic solution comes in the form of renal transplantation or peritoneal dialysis, the remaining group of patients consumes a comparably large percentage of NHS resources due to their dependence on haemodialysis.

Haemodialysis involves the filtering of blood via an external artificial kidney to remove toxins such as urea, creatinine and potassium, along with excess free water that would normally be excreted by the healthy individual’s kidneys. This method requires the passage of blood through an extracorporeal circuit across a semi-permeable membrane. Solutes, water and toxins cross the membrane in response to the hydrostatic pressure of the dialysate, or fluid on the other side of the membrane.

To ensure adequate quality of dialysis, a certain volume of blood must pass through the circuit in a certain period of time. To reliably achieve this blood flow volume access to the circulation must be robust. There are three main types of dialysis access, autogenous arteriovenous fistulae (AVF), prosthetic graft AVFs and dialysis catheters. The gold standard due to its inherently low infection and failure rates is the autogenous AVF. This is reflected in the National Kidney Foundation guidelines published in North America and the payment by results tariffs in the UK, which have incentivised haemodialysis via fistulae as opposed to other modes of access.

Prosthetic grafts have the advantage of spanning areas of insufficient venous anatomy to allow access creation, but carry a higher infection risk and are more prone to failure. Failure rates for autogenous fistula are approximately 0.2 events per patient/year compared to 0.8-1.0 events per patient/year for grafts. Dialysis catheters are dual lumen implanted plastic tubes that typically lie with their tips in the right atrium. The external portion of the catheter is free to connect to the dialysis machine. These can be temporary or tunneled under the skin in an attempt to increase their longevity by reducing the inherent infection risk associated with this type of dialysis access. Patients dialysing with catheters have a higher incidence of infection, hospitalisation and death. Central to avoiding this morbidity and mortality is a collaborative approach of interventional radiologists, nephrologists and surgeons. Each patient has a limited number of access sites with which to fashion fistulae. Maintenance of each site to ensure functionality and preventing thrombosis and failure. Assessment of the stenotic site with ultrasound will determine whether an antegrade or retrograde puncture in the venous limb of the fistula is performed. Utilising local anaesthetic, the fistula is usually accessed with a 6F 5cm beacon tipped vascular sheath. Stenoses are negotiated with a guidewire and the venous limb of the fistula. They occur most frequently at tortuous locations within the venous limb, close to the anastomosis, at the surgical mobilisation points (swing point), or terminal cephalic arch. The mechanism of stenosis is thought to be due to aggressive intimal hyperplasia in response to shear stress on the vein wall by high pressure fast flowing blood. Without treatment stenoses may become occlusions leading to access failure.

Pseudoaneurysm
Dialysis fistulae are regularly needled to allow haemodialysis. Repeated needling at the same site can result in vein or graft wall breakdown and the development of a pseudoaneurysm. While not all pseudoaneurysms arising from dialysis fistulae require treatment, those with thin overlying skin, scabs or bleeding will require treatment. Pseudoaneurysms become an increasing bleeding risk in the presence of a stenosis higher up the out-flowing vein, as the pressure within the pseudoaneurysm will become more arterial.

Failure to mature
When an artery and vein are Anastomosed, the vein increases in calibre in response to the arterialised pressure. Flow volumes increase dramatically. To achieve adequate dialysis, a vein must be at least 6mm wide, less than 6mm deep and sustain flow rates of 600mls/min. These parameters are not instantly achieved after anastomosis, but develop over a 6-12 week period. Failure of venous hypertrophy, or to achieve flow rates, is termed failure to mature and is most often due to arterial, anastomotic or venous stenosis. An alternative cause of failure to mature is the presence of competitive tributaries.

Tributaries
Tributaries and collaterals divert flow away from the vein intended for dialysis. The resulting reduction in flow may compromise dialysis quality, or may even prevent the vein from maturing.

Infection
Autogenous arteriovenous fistulae typically have lower infection rates than prosthetic grafts. Infections can be superficial, presenting like cellulitis, or can be deeper causing breakdown of the vein or graft wall. Focal collections around prosthetic grafts should be regarded with suspicion. Infected accesses have a higher tendency to thrombose.

Thrombosis
Thrombotic occlusion of an arteriovenous fistula is a medical emergency. It usually occurs as a result of stenoses reducing flow to such an extent that blood clots. Other causes include a fall in blood pressure and infection. Loss of dialysis access can result in failure to dialyse and hence risks life. Re-establishment of the functionality of the fistula is of prime importance.

Interventional therapies
Fistuloplasty
Dilatation of stenoses is critical in maintaining fistula functionality and preventing thrombosis and failure. Assessment of the stenotic site with ultrasound will determine whether an antegrade or retrograde puncture in the venous limb of the fistula is performed. Utilising local anaesthetic, the fistula is usually accessed with a 6F 5cm beacon tipped vascular sheath. Stenoses are negotiated with a guidewire and the venous limb of the fistula. They occur most frequently at tortuous locations within the venous limb, close to the anastomosis, at the surgical mobilisation points (swing point), or terminal cephalic arch. The mechanism of stenosis is thought to be due to aggressive intimal hyperplasia in response to shear stress on the vein wall by high pressure fast flowing blood. Without treatment stenoses may become occlusions leading to access failure.

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dilated with angioplasty balloons. Standard angioplasty bal-
oons are frequently not successful in dilating these fibrotic
stenoses and augmented balloon systems such as ultra high
pressure non-compliant angioplasty balloons or cutting bal-
oons are required. Angioplasty must dilate the stenosis to
return the fistula to normal function. The venous limb of
the fistula must have a palpable thrill and not be pulsatile
or impalpable post-procedure. Sonographic flow rate assess-
ment also determines success.

Stents are infrequently required, but can be employed
when elastic stenotic recoil threatens functionality and risks
failure. Recently the medical literature has focused on stent
design for AVFs, with the current opinion that stent grafts
may offer benefits over bare metal nitinol stents. 7 Future
avenues for research include the use of drug eluting stents
(DES) that release paclitaxel, a chemotherapeutic agent that
blocks cell proliferation and therefore inhibits neointimal
hyperplasia. Drug eluting balloons coated with cell prolifer-
ation inhibiting agents that are released into the intima at
the time of fistuloplasty may prove to be beneficial, but pub-
lished data is limited and costs may be prohibitive.

Pseudoaneurysm closure
Pseudoaneurysms are frequently encountered in dialysis
access. Any stenoses in the venous limb of the fistula should
to be balloon dilated to ensure depressurisation of the pseudo-
aneurysm before attempting definitive therapy. Percutaneous
treatment options are based on the pseudoaneurysm’s neck
size. Percutaneous injection of thrombin into the aneurysm
sac occludes the pseudoaneurysm when the neck of the
aneurysm is small, frequently secondary to a solitary needle
puncture. Recurrent needling at one site results in focal
breakdown of the vein or graft wall. These wider necked
pseudoaneurysms are best excluded by self-expanding stent
graft insertion.

Forced maturation technique
Interventions on immature fistulae carry a higher risk as
the veins are much narrower and prone to spasm, with a
higher propensity to cause thrombosis. Single sitting or mul-
tiple interventions are described. 1 The patient should be
assessed for an arterial inflow lesion. This can be treated by
standard angioplasty techniques. Small sclerotic venous
limbs can be dilated usually with successively larger bal-
oons, often starting at 5mm or 6mm and finishing at 8mm
or 9mm to achieve good luminal diameter and flow rates,
allowing successful dialysis.

Tributary occlusion
Tributary occlusion is rarely necessary and before embarking
on this technique the loss of veins via embolisation should be
strongly considered. Percutaneous techniques such as coil
embolisation or Amplatz plugging are an alternative to
surgical ligation. This does not require surgical incisions and
the medical literature reports satisfactory results. 9-10

Percutaneous thrombectomy
Prolonging the life of any fistula is paramount in the long
term health of a patient, given the finite number of
anatomic locations for forming a fistula. Techniques utilised
include chemical thrombolysis, surgical embolectomy and
percutaneous thrombectomy. Provision depends upon local
expertise and availability of equipment. Surgery involves
embolectomy with Fogarty balloon catheters and patchplasty
or bypass of stenotic segments. Percutaneous techniques do
not preclude the use of the fistula for dialysis and hence
may avoid the complications of temporary central venous
access. Long segments of stenosis or occlusion, pseudoa-
neurysms and central venous disease can all be dealt with.

Most operators use a standard technique of puncturing
the access in both antegrade and retrograde directions and
passing guidewires to the inflowing artery and central veins
to fully cross the occluded segment. Mechanical devices are
typically used to open the venous outflow segment of the
fistula first, followed by balloon angioplasty of this segment.

This is to ensure adequate outflow is established before
attempting to open the inflow.

Popular mechanical devices include the AngioJet device
(Medrad Interventional, MN, USA) and the Arrow Trerotola
percutaneous thrombectomy device (PTD) (Arrow
International, USA). AngioJet is a thrombectomy catheter
using a high pressure saline jet from the catheter tip gener-
ated by a pump system. Due to the Bernoulli principle,
this high velocity jet creates a low pressure zone at the
access. Any stenoses in the venous limb of the fistula should
be balloon dilated to ensure depressurisation of the pseudo-
aneurysm before attempting definitive therapy. Percutaneous
treatment options are based on the pseudoaneurysm’s neck
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Surgical repair of dialysis fistulae is possible, but requires
incisions that may limit dialysis in the short term and
require temporary catheter usage. Percutaneous techniques
do not prevent dialysis and are typically provided on an out-
patient basis. Clinical follow-up is essential to ensure the
fistula is functioning normally. Surveillance clinics provide
both clinical and sonographic functional assessment of fis-
tula flow rates, and can be provided within the radiology
department.

Early detection of failing fistulae can lead to rapid refer-
ral for intervention and preservation of quality dialysis. This
increases the workload and commitment required of the
interventional radiologist, but this patient-centric approach
where radiologists drive decision-making and treatment is
where the future of the subspecialty lies. However, a multi-
dersciplinary team approach, with frequent meetings involv-
ing nephrologists, dialysis nurses and dialysis access surgeons,
remains central to delivering efficient and reliable patient care.

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**FIGURE 1**
(a) Cephalic venous swingpoint stenosis approximately 2cm from the anastomosis with the brachial artery. (b) Fistuloplasty with a 6mm x 4cm ultrahigh pressure balloon, results in (c) improved luminal diameter.

**FIGURE 2**
(a) Wide necked pseudoaneurysm at a needle site with overlying skin thinning. (b) This has been excluded with a 7mm by 4cm Fluency stent graft.

**FIGURE 3**
(a) Fistulography from the brachial artery showing large cephalic fistula. The access had to be closed due to arm swelling in the presence of impassable central venous occlusion. (b) A 20mm Amplatzer plug is deployed in the peri-anastomotic cephalic vein.