Renal replacement therapy: implications for the surgeon

Renal replacement therapy comprises peritoneal dialysis, haemodialysis and renal transplantation. Patients undergoing renal replacement therapy often require surgery for a number of different reasons. This review summarizes likely surgical procedures for these patients and some of the common complications.

Currently over 50 000 patients receive renal replacement therapy in the UK (Shaw et al, 2013) and 7000 begin renal replacement therapy every year (Gilg et al, 2013). Renal replacement therapy comprises peritoneal dialysis, haemodialysis and renal transplantation. Patients with renal replacement therapy often require surgical procedures to facilitate this management. These can be for renal transplantation (3000 per annum in the UK; NHS Blood and Transplant, 2014), access for dialysis, the complications of that access or for associated comorbidity requiring surgical management. This article summarizes the likely surgical procedures, perioperative issues and common complications that surgeons caring for patients undergoing renal replacement therapy might encounter.

Renal access

Peritoneal dialysis requires a catheter to be placed into the peritoneal cavity to allow dialysis fluid to be passed into this cavity, using the peritoneum as a natural filter. Haemodialysis requires vascular access to remove blood from the body so that it may be passed through a filter and then back into circulation. The UK Renal Association (Fluck and Kumwenda, 2011) recommends an arteriovenous fistula as first choice for vascular access, an arteriovenous graft as second choice, a tunnelled venous catheter as third choice and a non-tunnelled catheter as an option of necessity.

Surgical procedures are necessary for all these types of renal access. Surgical procedures may also be necessary to manage complications such as arteriovenous graft thrombosis, arteriovenous fistula aneurysm, arteriovenous fistula stenosis or distal limb ischaemia. Complications of vascular access are common, account for 20% of haemodialysis patient admissions in the USA and cost in excess of $1 billion per year to manage (Feldman et al, 1996; Roy-Chaudhury et al, 2003). *Table 1* lists the complications of vascular access and their management. As can be seen surgical input is often necessary.

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Important factors in patients on renal replacement therapy

Vein preservation

Whether it is for pre- or postoperative bloods or administration of anaesthesia, venous access is an essential part of perioperative care. Arteriovenous fistulas are commonly created in the forearm between the radial or brachial artery and the cephalic vein. The technique was first described by Brescia and colleagues in 1966 and involves connecting the radial artery and cephalic vein to create a large, high pressure vessel which can be used for vascular access (*Figures 1a* and *b*).

Repeated venepuncture can damage veins, limiting the options available for arteriovenous fistulas to be fashioned. Given that the patency rates for arteriovenous fistulas are between 56% and 65% at 1 year and 30% and 45% at 5 years (Leapman et al, 1996; Wolowczyk et al,

Table 1. Surgical renal replacement therapy access options, complications and surgical management

Renal replacement therapy access options	Potential complications of access	Potential surgical management of complications
Arteriovenous fistula/graft	Bleeding, infection, stenosis, aneurysm, thrombosis, distal limb ischaemia	Angioplasty, thrombectomy, aneurysmectomy, formation of alternative access
Peritoneal dialysis catheter	Infection	Surgical removal of catheter, formation of alternative access
Central venous catheter	Infection, thrombosis	Removal of lines and formation of alternative access

2000), repeated formation of arteriovenous fistulae is often required. The UK Renal Association advocates that patients should be educated about the importance of forearm vein preservation and that clinicians should avoid unnecessary peripheral venous access in the upper limb where vascular access may be required (Fluck and Kumwenda, 2011).

Electrolyte/acid–base disturbances

Patients on renal replacement therapy depend on dialysis to maintain their electrolyte/acid–base balance. They are at particular risk of developing hyperkalaemia or acidaemia, which may result in cardiac arrhythmias or a catabolic metabolic state. This is common after surgical procedures. Intraoperative transfusion also increases the risk of developing hyperkalaemia intraoperatively (Brenowitz et al, 1977). Preoperative dialysis helps to minimize electrolyte/acid–base disturbances (Silberman, 1977) and checking preoperative and postoperative potassium levels is essential to establish the need for extra dialysis sessions.

Fluid balance

Patients on renal replacement therapy have a variable daily urine output (ranging from normal to complete anuria). Dialysis is the primary method of removing excess fluid in many patients. Patients on renal replacement therapy are dialysed to achieve a target 'dry weight' and often have a fluid restriction. It is important to get the fluid balance right. Excessive fluid administration may cause pulmonary oedema or poorly controlled hypertension, while inadequate fluid administration may result in profound hypotension, critical illness and compromise of vascular access. This may also be exacerbated by the induction of anaesthesia.

Working with renal physicians to establish a patient's fluid restriction and target dry weight will allow for both appropriate prescription of resuscitation fluid in the emergency setting and maintenance fluids when a patient is required to be nil by mouth, either preoperatively or as part of his/her surgical management (i.e. in the non-operative management of bowel obstruction). Fluid restriction should also be considered when prescribing insulin-based sliding scales for patients requiring renal replacement therapy in the perioperative period.

Blood transfusion and anaemia

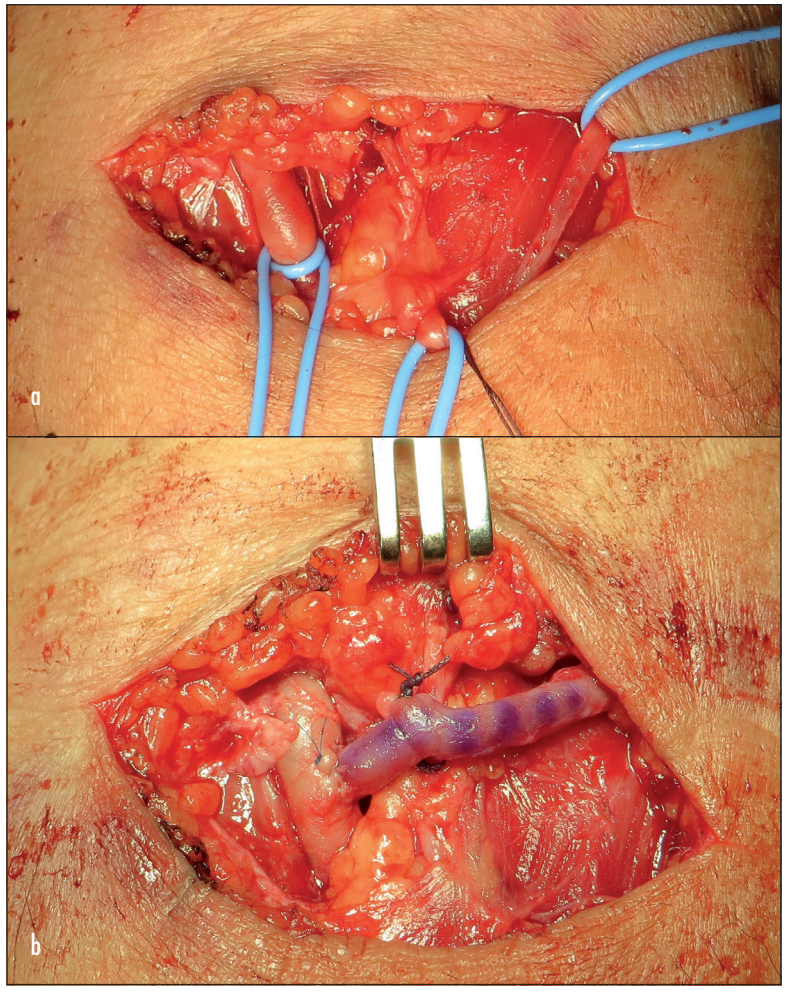
Patients with renal failure may produce less erythropoeitin and so are more likely to be anaemic before surgery. Some blood loss during operations is inevitable and there may be a need for perioperative blood transfusion. In addition to transfusion reactions, a potential complication of blood transfusion is antibody formation, which may jeopardize a patient's future ability to undergo transplantation by increasing the time spent on the transplant waiting list, increasing the rate of transplant graft rejection and worsening transplant graft survival rate (Macdougall and Obrador, 2013; Scornik et al, 2013).

The use of synthetic erythropoeitin and iron therapy to manage dialysis patients with anaemia is already advocated (Locatelli et al, 2013) and its use before elective surgery where significant blood loss can be anticipated can decrease the need for perioperative transfusion. Perioperative blood transfusions can result in electrolyte imbalance and fluid overload. Patients may therefore require additional dialysis outside their regular dialysis regimen to facilitate this.

Bleeding

Patients on renal replacement therapy can be at increased risk of perioperative bleeding. This is caused by many factors including hypertension and chronic uraemia, which has a detrimental effect on platelet function (Hutton and O'Shea, 1968; Galbusera et al, 2009). Despite there being no strong evidence that long-term oral anticoagulation therapy improves the survival of vascular access (Osborn et al, 2008), it often continues to be prescribed. Preoperative dialysis and correction of anaemia reduces the risk of bleeding secondary to uraemia (Galbusera et al, 2009). Management of perioperative hypertension by

Figure 1. Intraoperative formation of a brachiocephalic arteriovenous fistula. a. The cephalic vein (right) and brachial artery (left) are exposed. b. A brachiocephalic arteriovenous fistula is formed for renal access.



dialysis to target dry weight and continuation of antihypertensive medications is also advised.

Venous thromboembolism prophylaxis

Patients undergoing routine surgical procedures often receive low molecular weight heparin as part of venous thromboembolism prophylaxis. Low molecular weight heparin is predominantly excreted via the kidneys and can accumulate in patients with renal impairment or those already requiring renal replacement therapy. This may dramatically increase the bleeding risk postoperatively (Sonawane et al, 2006). Oral factor Xa inhibitors, such as rivaroxaban, are now recommended following elective major lower limb arthroplasty but should be avoided in patients on dialysis (Joint Formulary Committee, 2013). Unfractionated heparin is often preferred for perioperative venous thromboembolism prophylaxis in those receiving renal replacement therapy.

Calcium metabolism

Disorders of calcium metabolism are common in patients on renal replacement therapy. Renal osteodystrophy (also referred to as chronic kidney disease – mineral and bone disorder) is caused by hyperparathyroidism as a consequence of hypocalcaemia, hyperphosphataemia and failure of vitamin D_3 activation at the kidney. Chronic kidney disease – mineral and bone disorder may present with joint pain, bony pain, bony deformity or as a fracture. Radiographs may demonstrate osteopenia or fractures and chondrocalcinosis. Biochemically hypocalcaemia, hyperphosphataemia and a raised alkaline phosphatase level may be seen. Initial management involves restricted dietary phosphate intake, phosphate binding drugs and activated vitamin D supplements.

Endocrine surgeons may be asked to help manage tertiary hyperparathyroidism surgically in the form of parathyroidectomy and orthopaedic surgeons are more likely to be asked to manage these patients as they have up to a four-fold increased risk of fracture (Alem et al, 2000). Being aware of renal bone disease and its medical and surgical management will allow the clinician to manage renal bone disease and risk of fracture or hypocalcaemia more effectively.

Table 2. Perioperative consideration for patients on dialysis

Consideration	Action
Vein preservation during venepuncture	Avoid venepuncture in the forearm unless absolutely essential. The hands should be used where possible
Electrolyte/acid–base	Pre- and postoperative potassium levels should be measured to identify the need for extra perioperative dialysis sessions
Fluid balance	Awareness of target dry weights and fluid restrictions for patients on renal replacement therapy allows appropriate prescription of perioperative fluids
Blood transfusion and anaemia	Blood product transfusion should be avoided when not absolutely indicated, because antibody formation may decrease future chances of successful renal transplantation
	If transfusion is required, extra dialysis sessions may be required to prevent hyperkalaemia and/or fluid overload
	Preoperative erythropoietin or iron therapy may decrease the need for blood transfusion
Bleeding	Dialysis to target dry weight and to decrease uraemia, as well as management of anaemia, will decrease the risk of perioperative bleeding
Venous thromboembolism prophylaxis	Use of unfractionated heparin rather than low molecular weight heparin
Calcium metabolism and bone care	Renal replacement therapy patients are at increased risk of hypocalcaemia and fracture – medical and surgical management can help prevent these complications
Analgesia	Avoid codeine. Use of fentanyl and its derivatives is preferred, use morphine with caution at decreased doses and frequencies
Planning care	Elective procedures should be performed with dialysis facilities available for the perioperative period. In emergency operations, access to intensive care facilities able to offer renal replacement therapy or transfer to a centre able to offer renal replacement therapy is advised

Perioperative analgesia

Opioid analgesia is often required around surgical procedures. Opioid analgesics are renally excreted to varying degrees. Fentanyl and its derivatives are preferred because of their predominantly hepatic metabolism and predictable offset of action. Codeine should be avoided and morphine used with caution and at lower doses and frequencies if required (Dean, 2004; Trainor et al, 2011).

Planning perioperative care

In patients who are undergoing elective procedures, discussion with the patient's renal physician is essential in order to plan perioperative dialysis. The ideal setting for this discussion is a regular multidisciplinary team meeting involving clinicians frequently involved in the care of patients undergoing renal replacement therapy. Consideration of the need for high dependency care and for the procedure to be performed at a centre able to offer renal replacement therapy is also advisable.

Conclusions

Renal replacement therapy is common and patients undergoing this treatment invariably require surgical intervention, whether relating to the administration of this renal replacement therapy, management of the disease resulting in renal failure, where surgical intervention or trauma has necessitated renal replacement therapy or for an unrelated problem. An understanding of these issues will improve the clinician's ability to manage this increasingly large group of patients. **BJHM**

Conflict of interest: none.

Alem AM, Sherrard DJ, Gillen DL et al (2000) Increased risk of hip fracture among patients with end-stage renal disease. *Kidney Int* **58**: 396–9 (doi: 10.1046/j.1523-1755.2000.00178.x)

Brenowitz JB, Williams CD, Edwards WS (1977) Major surgery in patients with chronic renal failure. *Am J Surg* **134**: 765–9 (doi: 10.1016/0002-9610(77)90320-8)
Brescia MJ, Cimino JE, Appel K, Hurwich BJ (1966) Chronic hemodialysis using venipuncture and a surgically created arteriovenous fistula. *N Engl J Med* **275**(20): 1089–92
Dean M (2004) Opioids in renal failure and dialysis patients. *J Pain Symptom Manage* **28**(5): 497–504 (doi: 10.1016/j.jpainsymman.2004.02.021)
Feldman HI, Kobrin S, Wasserstein A (1996) Hemodialysis vascular access morbidity. *J Am Soc Nephrol* **7**(4): 523–35
Fluck R, Kumwenda M (2011) Renal Association Clinical Practice Guideline on vascular access for haemodialysis. *Nephron Clin Pract* **118** (Suppl 1): c225–40 (doi: 10.1159/000328071)
Galbusera M, Remuzzi G, Boccardo P (2009) Treatment of bleeding in dailysis patients. *Semin Dial* **22**(3): 279–86 (doi: 10.1111/j.1525-139X.2008.00556.x)
Gilg J, Rao A, Fogarty D (2013) UK Renal Registry 16th annual report: chapter 1 UK renal replacement therapy incidence in 2012: national and centre-specific analyses. *Nephron Clin Pract* **125**(1-4): 1–27 (doi: 10.1159/000360020)
Hutton RA, O'Shea MJ (1968) Haemostatic mechanism in uraemia. *J Clin Pathol* **21**: 406–11
Joint Formulary Committee (2013) *British National Formulary.* 67th edn. BMJ Group and Pharmaceutical Press, London
Leapman SB, Boyle M, Pescovitz MD et al (1996) The arteriovenous fistula for hemodialysis access: gold standard or archaic relic? *Am Surg* **62**(8): 652–6
Locatelli F, Barany P, Covic A et al (2013) Kidney Disease: Improving Global Outcomes guidelines on anaemia management in chronic kidney disease: a European Renal Best Practice position statement. *Nephrol Dial Transplant* **28**(6): 1346–59 (doi: 10.1093/ndt/gft033)
Macdougall IC, Obrador GT (2013) How important is transfusion avoidance in 2013? *Nephrol Dial Transplant* **28**(5): 1092–9 (doi: 10.1093/ndt/gfs575)
NHS Blood and Transplant (2014) Organ Donation and Transplant Activity Report 2013/2014. www.organdonation.nhs.uk/statistics/transplant_activity_report/ (accessed 18 May 2015)
Osborn G, Escofet X, Da Silva A (2008) Medical adjuvant treatment to increase patency of arteriovenous fistulae and grafts. *Cochrane Database Syst Rev* (4): CD002786 (doi: 10.1002/14651858.CD002786.pub2)
Roy-Chaudhury P, Duncan H, Barrett W et al (2003) Vascular brachytherapy for hemodialysis vascular access dysfunction: exploring an unmet clinical need. *J Invasive Cardiol* **15** (Suppl A): 25A–30A
Scornik JC, Bromberg JS, Normal DJ et al (2013) An update on the impact of pre-transplant transfusions and allo-sensitization on time to renal transplant and on allograft survival. *BMC Nephrol* **14**: 217 (doi: 10.1186/1471-2369-14-217)
Shaw C, Pitcher D, Pruthi R, Fogarty D (2013) UK Renal Registry 16th annual report: chapter 2 UK RRT prevalence in 2012: national and centre-specific analyses. *Nephron Clin Pract* **125**(1-4): 29–53 (doi: 10.1159/000360021)
Silberman H (1977) Renal failure and the surgeon. *Surg Gynecol Obstet* **144**(5): 775–84
Sonawane S, Kasbekar N, Berns JS (2006) The safety of heparins in end-stage renal disease. *Semin Dial* **19**(4): 305–10 (doi: 10.1111/j.1525-139X.2006.00177.x)
Trainor D, Borthwick E, Ferguson A (2011) Perioperative management of the hemodialysis patient. *Semin Dial* **24**(3): 314–26 (doi: 10.1111/j.1525-139X.2011.00856.x)
Wolowczyk L, Williams AJ, Donovan KL et al (2000) The snuffbox arteriovenous fistula for vascular access. *Eur J Vasc Endovasc Surg* **19**(1): 70–6 (doi: 10.1053/ejvs.1999.0969)

KEY POINTS

- As a surgeon looking after patients on renal replacement therapy, it is vital to be aware of:
  - Forearm vein preservation for vascular access
  - Fluid and electrolyte balance
  - Bleeding risk and transfusions
  - Venous thromboembolism prophylaxis.
- Consideration of these topics and coordinating patient care with renal physicians will enable surgeons to give the best care for this group of patients.