



Anaesthesia for Chronic Renal Disease and Renal Transplantation

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Abstract

The aim of this article is to present the features of chronic renal disease (CRD) that influence the conduct of anaesthesia and to introduce some of the anaesthetic techniques used for this challenging group of patients, including anaesthesia for renal transplantation.

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1. Introduction

Many patients presenting for urological surgery have chronic renal disease (CRD). They have unique pathophysiology relating to both CRD and its underlying cause and therefore present a challenge to surgeons and anaesthetists. Considerable advances in renal replacement therapy (RRT) and renal transplantation mean that a greater number of these patients are presenting for anaesthesia to assist vascular access procedures and renal transplantation. As their survival increases they also present more frequently for surgery unrelated to their renal disease. The aim of this article is to present the features of CRD that influence the conduct of anaesthesia and to introduce some of the anaesthetic techniques used for this group of patients.

1.1. Aetiology of CRD

The aetiology of CRD is varied. In the UK the most common causes are diabetes (30%), hypertension

(24%) and glomerulonephritis (17%). In 20% of cases the cause is unknown. The effects of renal disease are seen in all organ systems and mediated by accumulation of toxic metabolic products and endocrine dysfunction.

1.2. Prevalence of CRD

In 2002 there were an estimated 140,000 patients in the UK with CRD under the care of renal physicians. 37,000 patients were undergoing renal replacement therapy: 46% with a renal transplant, 37% haemodialysis, and 16% with ambulatory peritoneal dialysis [1].

2. Pathophysiological and pharmacological changes relevant to anaesthesia in patients with CRD

2.1. Physiological effects

CRD causes multi-system dysfunction. This can be mediated by the primary disease process causing

Box 1. Effects of uraemiaCardiovascular system

Hypertension, ischaemic heart disease, cardiac failure, pericarditis (severe uraemia)

Respiratory system

Pulmonary oedema, pleural effusion, respiratory infection

Gastro-intestinal

Stress ulceration, delayed gastric emptying, malnutrition

Central Nervous System

Peripheral neuropathy, autonomic neuropathy, mental slowing, convulsions, coma

Renal

Fluid and electrolyte imbalance, altered drug handling

Haematological

Anaemia, bleeding predisposition

Immunological

Immunosuppression (physiological, pharmacological)

renal failure (e.g. diabetes) or by the effects of uraemia or both **Box 1**.

Cardiovascular disease is common. There is a high incidence of coronary artery disease which tends to follow a rapidly progressive course [2]. In addition, hypertension and uraemia cause left ventricular hypertrophy and dilatation, with about a third of patients having clinically relevant cardiac failure [3]. CRD in younger patients increases the risk of perioperative cardiovascular mortality one hundred fold [4]. This has direct relevance to anaesthesia for both major and minor surgical procedures.

2.2. Pharmacological effects

Many drugs are eliminated from the body by the kidneys. Water-soluble substances are usually excreted unchanged, whereas lipid-soluble molecules are usually converted to water-soluble metabolites, and then excreted in the urine. CRD causes a reduction of the rate of renal excretion, because of impairment of glomerular filtration and renal tubular function. In turn this can lead to accumulation of the drug and its metabolites. The consequences of this depend on the characteristics of the drug and the severity of renal failure **Box 2**.

Box 2. Examples of drug actions influenced by CRDNon-depolarising neuromuscular blocking drugs

Unpredictable duration of action or incomplete reversal of paralysis

Antibiotics

Unwanted side effects: e.g. Gentamicin: ototoxicity or nephrotoxicity

Opioids

Unwanted side effects of active metabolites: e.g. Morphine-6-glucuronide: respiratory depression

These pathophysiological and pharmacological effects exert a considerable influence on the way patients with CRD respond to anaesthesia. In the following sections we shall describe how their anaesthetic management may be altered to reduce perioperative complications.

3. Principles of anaesthesia for patients with CRD**3.1. Preoperative preparation**

The aim of preoperative preparation of patients with CRD is to identify and optimise any pre-existing pathophysiology in order to minimise the risk of anaesthesia and surgery. This requires a multidisciplinary approach involving anaesthetists, surgeons and renal physicians. Because CRD affects all organ systems, it is important to identify and optimise existing organ pathology. A systems approach is therefore useful.

3.1.1. Organ systems review**3.1.1.1. Cardiovascular system**

3.1.1.1.1. Ischaemic heart disease. CRD is strongly associated with an accelerated form of ischaemic heart disease, which should be identified and optimised to reduce perioperative cardiac morbidity and mortality. Other forms of vascular disease (e.g. cerebrovascular disease and hypertension) and resulting end-organ dysfunction (e.g. CRD, cardiac failure) are associated with adverse perioperative cardiac events [5]. Therefore, in patients with CRD a positive history should be actively sought and investigated appropriately. According to published guidelines all patients with co-morbidity associated with cardiovascular disease, including CRD, should receive a baseline electrocardiogram (ECG) regardless of the severity of surgery [6]. Cardiopulmonary exercise testing (CPX) is a novel method of dynamic cardiorespiratory assessment. It appears to be able to predict patients at high risk of perioperative cardiovascular mortality more accurately than other methods [7], and may become a powerful tool in preoperative assessment in the future.

In patients with significant cardiovascular morbidity consideration should be given preoperatively to:

- Optimisation of long-term medical therapy
- Further investigation of cardiorespiratory function
- Preoperative optimisation in an intensive care environment

3.1.1.1.2. *Vascular access.* Patients with CRD may have difficult IV access. Access should be considered and planned preoperatively. Current or potential future fistula sites should be avoided, including all forearm and antecubital veins if possible. Central venous cannulation may also be difficult if haemodialysis catheters have previously been sited in the central veins, and the use of ultrasound guidance is recommended [8].

3.1.1.2. *Renal system.* Patients with CRD are often well informed of their condition and under the long-term care of renal physicians. A detailed background renal history enables perioperative renal support to be planned.

3.1.1.2.1. *Considerations in the renal history.*

- Usual fluid intake (may be restricted, and therefore caution with perioperative intravenous fluids is required)
- Usual daily urine output (may be zero)
- Regime of renal replacement therapy (e.g. frequency of dialysis)
- Renal function (baseline and current)
 - Serum urea and creatinine concentration
 - Glomerular filtration rate
- Serum electrolyte concentration
 - Sodium
 - Potassium

3.1.1.2.2. *Timing of preoperative dialysis.* Haemodialysis and peritoneal dialysis are renal replacement therapies used to remove metabolic waste material and fluid from the circulation. In addition, these processes also attempt to normalise fluid volume and electrolyte concentrations. Anaesthesia and surgery should take place in a near normal physiological environment and it therefore seems logical that dialysis should take place just before surgery. However, the dialysis process may itself cause physiological disturbance. Effects of recent dialysis include:

- Fluid depletion and redistribution to extravascular spaces resulting in depletion of intravascular volume
- Electrolyte disturbance, especially hypokalaemia
- Residual anticoagulation from heparinisation of the haemodialysis circuit.

Dialysis is therefore usually scheduled about 12–24 hours prior to surgery. The ionic content of the dialysate may be altered to influence the amount and composition of fluid removed and so collaboration with the renal physicians pre-

operatively is very important. A post-dialysis measurement of serum electrolytes is required before surgery as dialysis induced electrolyte disturbance can predispose to intraoperative cardiac dysrhythmias.

3.1.1.2.3. *Correction of serum potassium abnormalities.* CRD patients may present preoperatively with hyper- or hypokalaemia. The former is due to impaired renal potassium elimination and the latter usually due to excessive removal by recent dialysis. This patient subgroup is normally tolerant of large variations of serum potassium concentration, so discussion with renal physicians is advisable prior to correction.

Emergency treatment of hyperkalaemia is indicated if there are ECG manifestations such as bradycardia, PR prolongation, QRS widening, peaked T waves, AV block. Treatment includes:

- Basic and advanced life support measures as required
- Continuous cardiac monitoring and large bore IV access
- Cardiac membrane stabilisation using calcium chloride or calcium gluconate
- Promote intracellular shift of serum potassium using an infusion of insulin and dextrose whilst monitoring plasma glucose concentrations
- Excretion of excess potassium (method depends on intrinsic renal function): options include diuretic therapy to promote renal excretion, oral/rectal cation exchange resins and renal replacement therapy using dialysis or haemofiltration.

Emergency correction of hypokalaemia is only required if associated with cardiac arrhythmias or ECG changes. These changes are variable and include flattened or inverted T waves, prominent U waves that appear as QT prolongation, ST depression and both atrial and ventricular tachyarrhythmias. Involvement of a renal physician is strongly advised prior to starting potassium replacement. Treatment includes:

- Basic and advanced life support measures as required
- Continuous cardiac monitoring and large bore IV access
- Intravenous potassium replacement diluted as appropriate, observing for cardiac arrhythmias

3.1.1.3. *Other organ systems.* A summary of pathologies affecting other organ systems and preoperative management is outlined in Box 3.

Box 3. Systems review of CRD patients and preoperative considerations

System	Pathophysiological process	Preoperative consideration
GI	Reflux	Antacid prophylaxis
Neurological	Delayed gastric emptying	Alteration of anaesthetic technique to protect airway
	Peripheral neuropathy	Positioning on operating table Pressure area care
	Autonomic neuropathy causing intraoperative haemodynamic instability	Intraoperative invasive blood pressure monitoring Anaesthetic drug dose alteration
Haematological	Anaemia	Consider acceptable perioperative haemoglobin concentration
Immunological	Immunosuppression	Antibiotic prophylaxis Steroid supplementation Minimise invasive procedures

3.1.2. Preoperative optimisation

Some patients are at a greater risk of perioperative morbidity and mortality than others. It is difficult to predict the patient and surgical factors that increase risk. Renal insufficiency alone is an intermediate risk factor for perioperative adverse cardiac events according to widely accepted guidelines [5]. All patients, regardless of risk, benefit from thorough preoperative preparation and optimisation of co-morbidities. There may be some additional benefit of a period of preoperative physiological optimisation in the intensive care unit (ICU) for those patients with the highest perioperative risk, including patients with severe cardiovascular disease undergoing major surgery [9]. However there is no specific evidence of such aggressive preoperative optimisation strategies being beneficial in patients with CRD. Many trials have attempted to improve preoperative tissue oxygen delivery to high-risk patients by increasing oxygen uptake using goal-directed therapy with fluid and inotropic drugs. Some have shown a significant reduction in 30-day postoperative mortality [10,11].

3.2. Anaesthetic techniques suitable for patients with CRD

Patients with CRD may undergo elective or emergency surgery, related or unrelated to their underlying renal dysfunction. Anaesthetic techniques for these situations are outlined in the following paragraphs, illustrated by a detailed discussion of anaesthesia for vascular access surgery. This is followed by the principles of anaesthesia for other elective and emergency surgery and for renal transplantation.

3.2.1. Vascular access surgery

Patients with ESRD undergoing renal replacement therapy with intermittent haemodialysis will often

require anaesthesia and surgery to form an arterio-venous fistula or graft.

The aims of anaesthesia for vascular access surgery are to:

- Ensure intraoperative patient comfort
- Optimize surgical conditions
- Minimise risk of anaesthetic complications, e.g. perioperative cardiac events,
- Optimise postoperative state – avoidance of prolonged sedation, minimal requirement for strong postoperative analgesia

Anaesthetic techniques include

- Local anaesthetic (LA) infiltration (with or without sedation)
- Regional anaesthesia (RA) using brachial plexus local anaesthetic block (with or without sedation)
- General anaesthesia (GA)

There are advantages and disadvantages to each technique. The choice of technique is based on individual patient assessment, the preferences of the patient and local practice [Box 4](#).

3.2.1.1. Local anaesthetic infiltration. LA infiltration of the surgical field by the surgeon is the most physiologically stable of the anaesthetic techniques, and is therefore used in patients with severe co-morbidity. Its main disadvantage is that it is the least well tolerated by patients of all the anaesthetic options. Also, in contrast to regional and general anaesthesia, LA infiltration does not improve the flow characteristics of the brachial artery [12].

3.2.1.2. Regional anaesthesia. Regional anaesthesia of the upper limb requires LA block of the brachial plexus. This offers many advantages over other techniques, including intraoperative haemodynamic stability

Box 4. Comparison of anaesthetic techniques for CRD patients

	Technical difficulty	Patient tolerability	Post operative analgesia	Physiological disturbance	General complications
LA	Simple	Often poor	Variable	Insignificant	<ul style="list-style-type: none"> • Systemic LA toxicity • Inadvertent vascular injection
RA	May be complex	Variable	Good	Mild	<ul style="list-style-type: none"> • See Box 6
RA and sedation	As for RA	Good	Good	Moderate	<ul style="list-style-type: none"> • As for RA • Side effects of sedation drugs • Unexpected loss of airway
GA	Variable	Good	Variable	May be severe	<ul style="list-style-type: none"> • Airway protection and maintenance • Cardiovascular instability • Unpredictable drug effects • Perioperative blood glucose control in diabetic patients

and good postoperative analgesia. There is also evidence that it improves vascular flow via regional sympathectomy [13], although evidence of improved graft survival is lacking. Successful blockade adequate for sole anaesthesia may be technically difficult and time consuming and may require supplementation with LA by the surgeon. Several approaches to the brachial plexus have been described (Box 5), each with its own set of indications and complications. General complications are outlined in Box 6, the incidences of which vary according to the specific approach used.

3.2.1.3. *Regional anaesthesia and sedation.* An alternative is a combined approach using RA and sedation. This improves patient tolerability of RA whilst maintaining its advantages over LA infiltration and GA (minimal physiological disturbance, improvement in regional vascular flow and good postoperative analgesia).

3.2.1.4. *General anaesthesia.* Patients with CRD have multiple GA risk factors, as described previously in this article. However there is no evidence that GA presents a higher risk than other techniques. In general, there is a lack of research comparing

outcomes from different anaesthetic methods. In one retrospective study there was no increase in mortality, cardiac morbidity or fistula failure in patients undergoing procedures under general anaesthesia compared to LA infiltration or RA brachial plexus block [20], although the comparison was underpowered. Patients often have an expectation of general anaesthesia when presenting for surgery. With careful planning they can be offered GA with minimal increased risk.

3.2.2. Other elective procedures

As the long-term management of CRD improves and life-expectancy increases, patients are more frequently presenting for elective surgery unrelated to their renal disease. Perioperative care follows the principles already described in this article and a recently published article in this series [21].

Summary of perioperative considerations

- Anaesthetic options – general, regional or local anaesthesia
- Airway management
- Vascular access
- Fluid and electrolyte management

Box 5. A summary of different approaches to the brachial plexus. Advantages of each are outlined with their important problems (percentage incidences)

	Advantages	Specific problems
Axillary	<ul style="list-style-type: none"> • Technically simple • Few serious complications 	<ul style="list-style-type: none"> • Slow onset (15–25 minutes, [14]) • ‘Missed’ radial and musculocutaneous nerve (50%, [15])
Supraclavicular/Infraclavicular	<ul style="list-style-type: none"> • Effective anaesthesia • Low incidence of ‘missed nerves’ • Fast onset 	<ul style="list-style-type: none"> • Technically difficult. • Pneumothorax (supraclavicular, 0.2–4%, [16]) • Subclavian artery injury (2%, [17])
Interscalene	<ul style="list-style-type: none"> • Effective anaesthesia • Lower risk of pneumothorax than supra/infra-clavicular block 	<ul style="list-style-type: none"> • Inadequate block of ulnar nerve (50%, [18]) • Inadvertent LA injection to vertebral artery, epidural, subdural or subarachnoid spaces (case reports only) • Pneumothorax (0.2%, [17]) • Phrenic nerve block (100%, [19])

Box 6. General complications of brachial plexus block

Inadequate anaesthesia/analgesia

Needle malposition distant from brachial plexus, 'Missed' nerves

Local anaesthetic toxicity

Idiosyncratic (anaphylactic reactions), Dose related toxicity

Injury to nearby structures

Neuronal

Mechanical (needle trauma)

Chemical (secondary to infiltrated drug, e.g. LA)

Vascular

Arterial

Venous

Lung pleura

Pneumothorax

Unintended destination of LA

Intravascular injection, subarachnoid or epidural injection, blockade of phrenic nerve, cervical sympathetic chain or recurrent laryngeal nerve (RLN)

- Blood transfusion
- Immune function and antibiotic prophylaxis
- Steroid supplementation

3.2.3. *Unplanned urgent and emergency surgery*

Patients may present for unplanned surgery relating or coincidental to their renal disease. Examples of renal disease related surgical problems include

- Haemodialysis vascular access problems – blocked fistula
- Peritonitis secondary to infected peritoneal dialysis catheter

Unplanned surgery has many anaesthetic implications, both generic and specific to patients with CRD.

General Considerations:

- Presenting condition causing physiological disturbance (e.g. abdominal sepsis, bleeding, GI obstruction)
- Co-morbidities not optimised and affected by presenting condition (e.g. cardiovascular disease, diabetes)
- A full stomach in a patient requiring emergency surgery introduces the risk of regurgitation and aspiration under general anaesthesia. This may require a rapid sequence intubation technique.
- Postoperative care environment (e.g. intensive care unit)
- Psychological stress

Specific implications for CRD

- Fluid and electrolyte disturbance – many influences including presenting condition, chronic renal function, dialysis regime
- Immune suppression increases risk of postoperative sepsis

A preoperative assessment with baseline investigations is always necessary, except in a dire emergency. A multi-disciplinary approach should be used, including surgeons, anaesthetists, renal physicians, intensive care physicians and microbiologists as appropriate. Senior anaesthetic input is required for these difficult patients. Anaesthetic technique varies according to the individual situation, but attention to detail is of paramount importance.

3.3. *Postoperative management*

3.3.1. *Environment*

Most patients with CRD can return to a surgical hospital ward postoperatively. Admission to high dependency or intensive care facilities may be suitable for patients with significant co-morbidity and after major surgical procedures. The decision to admit a patient to such an environment requires input from critical care physicians. An important factor in the decision is often the limited resources available for these facilities, a problem that varies between countries. In the UK guidelines for appropriate admissions have been published by the Department of Health [22]. Principles include

High dependency care

- Postoperative patients who need detailed monitoring for longer than can be accommodated in a recovery unit
- Unstable patients requiring greater observation than can be provided on a general ward
- Patients requiring single organ support, excluding advanced respiratory support
- Patients no longer needing Intensive Care but who are not yet well enough to be returned to a general ward

Intensive Care

- Patients with respiratory failure requiring advanced respiratory support
- Patients requiring support of two or more organ systems

- Patients with chronic co-morbidity of one or more organ systems that require support for an acute reversible failure of another system

3.3.2. Analgesia

Alternatives can be categorised into local, regional and systemic analgesia. They may be combined to improve analgesic quality and reduce adverse effects. Advantages and disadvantages of each are described.

3.3.2.1. Intraoperative LA infiltration. Advantages: This is the simplest form of postoperative analgesia, often used in conjunction with other techniques. No postoperative management is required, with a reduced requirement for systemic analgesia.

Disadvantages: Alone LA infiltration is often inadequate with a finite duration of action. Inadvertent intravascular injection and LA toxicity is possible but unlikely. There is a risk of surgical wound haematoma.

3.3.2.2. Regional analgesia (e.g. epidural analgesia, brachial plexus block). Advantages: RA provides both intra- and postoperative analgesia with reduced requirement for systemic analgesic drugs. Epidurals potentially reduce the incidence of postoperative respiratory complications [23] and venous thromboembolic events, especially in orthopaedic surgery [24]. Importantly, however, there are as yet no studies investigating the benefits of epidural analgesia in patients with CRD.

Disadvantages: Some disadvantages have been discussed in a previous section of this article. Ongoing nursing and anaesthetic input is required into the postoperative period to prevent potential complications such as analgesic failure or hypotension.

3.3.2.3. Systemic analgesia. There is a wide range of systemic analgesia available, each with a profile of indications, contra-indications and side effects. A detailed discussion of each class of drug is outside the realm of this article, but the principles of systemic analgesia are outlined.

3.3.2.3.1. The World Health Organisation Pain Ladder. The World Health Organisation Pain Ladder [25] was initially developed for use in cancer pain, but has been adopted as a guide for the provision of postoperative systemic analgesia [Box 7](#).

The use of NSAIDS including COX II selective analgesics is avoided in patients with CRD since they have well documented renal side effects with subsequent loss of glomerular function [26,27].

Box 7. The WHO Pain Ladder

There are three rungs on the ladder. The patient is moved up a rung if pain is poorly controlled.

- Rung 1 – Simple analgesics (paracetamol, NSAIDS)
- Rung 2 – Addition of weak opioids (e.g. tramadol/codeine)
- Rung 3 – Addition of strong opioids (e.g. morphine)

At each stage it is important to consider including therapy to reduce side effects (e.g. antiemetics) and adjuvant drugs to attempt to reduce doses of systemic analgesia (e.g. local or regional analgesic techniques).

3.3.2.3.2. Route of administration. There are different options for the administration of postoperative systemic analgesia. Traditional nurse-administered oral or intramuscular analgesia is most frequently employed. This is simple and allows regular assessment of pain control by nursing staff. However the onset of analgesia is slow after each dose, there are potential delays in administration and the regime lacks patient autonomy. More recently patient controlled administration of intravenous opioid analgesia (PCA) has been used safely and successfully in the early postoperative period. This encourages patients to titrate analgesia to their perceived pain. It provides fast onset pain relief and is empowering to patients. There are several disadvantages, however. It requires intravenous access and the availability of experienced staff. There is potential for opioid overdose with equipment malfunction.

3.3.2.3.3. Opioids. The choice of opioid is an important consideration in CRD patients. The action of opioids is curtailed by redistribution away from the central and peripheral opioid receptors to fat stores and then by hepatic and renal elimination. If renal elimination is impaired then the beneficial and unwanted effects of opioids can be accentuated and prolonged. Accumulation of morphine and its metabolites may be a particular problem and a cause of delayed respiratory depression postoperatively. Fentanyl, a faster acting synthetic opioid is preferred for IV PCA opioid administration in CRD. It has a preferable pharmacokinetic profile with fast onset and offset times and it has less propensity for the accumulation of active metabolites that cause side effects. An area of current interest is in the use of buprenorphine either as a patch or sublingually. This opioid is almost exclusively metabolised by hepatic pathways and theoretically should not accumulate in CRD [28].

Therefore there is clearly a wide choice of techniques available for postoperative analgesia. Choice of technique depends on a variety of patient, surgical and institutional factors:

Patient factors

- Patient preference
- Physical and mental capabilities (e.g. Patient Controlled Analgesia)
- Co-morbidities (e.g. bleeding diathesis and epidural analgesia)

Surgical factors

- Surgical procedure and anatomical site

Institutional factors

- Anaesthetic experience and out-of-hours support
- Postoperative nursing experience

4. Renal transplantation

Renal transplant is one of the most efficient treatments for End Stage Renal Failure (ESRF) in terms of cost, survival benefit and quality of life. There is a 40–60% reduced mortality in those transplanted compared to those remaining on dialysis [29].

The first renal transplant occurred between identical twins in the mid 1950s. The first description of anaesthesia for transplant was in the 1960s between living donor identical twins using a spinal anaesthetic technique [30]. With the introduction of effective renal dialysis between 1960s and 1970s there has been a large increase in the number of patients with end stage renal failure surviving to be considered for renal transplantation. Over the last 10 years, demand for renal transplant has grown by around one third although supply of donor organs has remained approximately the same. For this reason the number of living donors has gradually risen to address this increased demand, requiring these otherwise healthy individuals to undergo major surgery. There may yet be future consequences of organ donation to these individuals in terms of reduced renal reserve, but this will not be apparent at time of renal donation. The latest figures for those awaiting transplant and of those transplants completed are outlined in Box 8.

4.1. Selection of potential recipients

All ESRF patients should be considered for transplant unless there are specific contraindications: predicted patient survival of <5 years, predicted graft loss of >50% at one year, patients who are

Box 8. Renal transplant statistics: UK, 2005 [31]

Numbers of adult patients registered for transplant

- Kidney 5773
- Kidney and Pancreas 90

Transplant operations completed

- Kidney cadaveric donor 1205
- Kidney living donor 589
- Kidney pancreas 107

unable to comply with the required immunosuppression regimen, and those who cannot tolerate immunosuppression.

All patients are extensively evaluated by renal physicians and transplant surgeons prior to entering the transplant programme, with specialist opinions sought from other disciplines as appropriate. As the current waiting time for an organ is 2 years in the UK [31] there is usually ample time for investigation and patient preparation.

4.2. Anaesthetic management

Renal transplant surgery may be performed under regional or general anaesthesia. The former was used exclusively in the early history of renal transplant surgery [29], but general anaesthesia (GA) with paralysis and controlled ventilation is now the method of choice. GA provides the most stable haemodynamics and good muscle relaxation for surgical access.

4.2.1. Premedication

Gastric paresis, gastritis and reflux disease are common in this patient group necessitating antacids as outlined previously. Many patients are also extremely anxious during this emotive period and anxiolytics are appropriate in this circumstance.

4.2.2. Intraoperative monitoring

This should consist of standard minimum monitoring in addition to core temperature and central venous pressure (CVP). CVP is measured via a central venous catheter sited after induction of anaesthesia, usually in the right internal jugular vein. Direct arterial pressure monitoring may be useful for some patients but is not mandatory and care should be taken when choosing an insertion site so as not to compromise future fistula formation. If the patient is likely to require new haemodialysis postoperatively then access should be sited at induction. As with all invasive procedures, strict asepsis should be used as this patient group is at higher risk of infective complications due to the post operative immunosuppression.

4.2.3. Intraoperative graft optimisation

Future graft function is directly related to several factors including: warm ischaemic time (harvest time and transplant); cold ischaemic time (e.g. storage >24 hours); transplanted graft perfusion and pre-donation graft state.

In order to maximise graft function the intraoperative aims should be a warm, well-perfused patient with a systolic arterial pressure >130 mm Hg. Traditionally aggressive volume loading has been recommended using volumes up to 30 ml/kg of warmed crystalloid solution, aiming for a CVP >15 mm Hg; however patients with pre-existing cardiac disease or impaired cardiac function are at risk of volume overload, leading to pulmonary oedema necessitating a period of postoperative ventilation. More recently it has been suggested that 15 ml/kg, aiming for a CVP 7–9 mm Hg at the point of reperfusion may be associated with equally good graft recovery, whilst reducing the risks associated with volume overload [32].

Adjuvant drugs are also commonly employed in an attempt to improve graft recovery and function. Evidence for the effectiveness of these agents however is often sparse or contradictory and not supported by the Cochrane review on perioperative renal protection [33], although these studies did not deal with the transplanted kidney. Transplant units have their own protocols for these adjuvant drugs, but those commonly used are mannitol, furosemide and dopamine.

Mannitol in a dose of 0.25–0.5 g/kg leads to an osmotic diuresis and intravascular volume expansion. It also has free radical scavenging properties which have been suggested as offering some protection against ischaemic injury. It may also promote renal artery dilatation and thus improve blood flow through the transplanted organ [34].

Furosemide in low to high dose (40–250 mg) has also been used and may result in massive diuresis in well functioning grafts, which may make fluid management difficult. The use of furosemide may be beneficial in promoting urine flow and avoiding oliguria but the benefits in terms of improved graft function remain unclear. High dose boluses should be used with caution, as they are associated with ototoxicity.

Dopamine use in low 'renal' dose infusions (2–3 mcg/kg/min) is contentious as only a few small studies have shown an improvement in urine output or creatinine clearance, compared to several large studies showing no such improvements [35]. A recent study involving living donor nephrectomy also found no beneficial effect to

either donor or recipient from low dose dopamine infusion [36].

4.2.4. Postoperative care

Most renal transplant patients have their anaesthesia reversed and are extubated at the end of surgery. Postoperative patients are usually nursed in a high dependency setting on a renal ward. Only 1% requires admission to an Intensive Care Unit (ICU), usually as a consequence of fluid overload or sepsis. Postoperative management goals are to maintain a well perfused patient with a sufficient blood pressure to allow good graft function. New oliguria (<50 ml/hr) in a well filled cardiovascularly stable patient should trigger surgical discussion and assessment of graft blood supply with Doppler ultrasound or surgical re-exploration.

4.2.5. Pain

Postoperative pain is usually mild to moderate following renal transplantation. Morphine is most commonly used for analgesia intraoperatively and in the UK is usually continued postoperatively by PCA as described above [37]. Addition of regular paracetamol has an opioid sparing effect and will potentially reduce the incidence of opioid side effects. Should renal function deteriorate, the metabolites of morphine may accumulate as described above.

NSAIDs should be avoided in this group of patients due to their potential renal toxicity and GI tract erosions.

5. Conclusion

Patients with CRD are complex medical cases and present unique challenges to the anaesthetist. They come with all the sequelae of CRD and of the disease state that caused their CRD. As age is no longer a barrier to renal transplantation in the UK, increasing age with associated morbidity must also be considered.

The perioperative care of these patients should be arranged and carried out by senior staff from the departments of surgery, anaesthesia, and renal medicine and in appropriate ward settings. Failure to care for these patients well has implications for graft survival in transplantees and morbidity in those patients with CRD.

As live related donation increases the multi-disciplinary team must make allowances to care for otherwise healthy individuals with only 50% of their original renal capacity.

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CME questions

Please visit www.eu-acme.org/europeanurology to answer these EU-ACME questions on-line. The EU-ACME credits will then be attributed automatically.

1. Concerning General Anaesthesia and CRD
 - A. Gastric aspiration risk is increased
 - B. Anaemia should be corrected to normal values pre-operatively
 - C. Strong opioids are contra-indicated for post-operative analgesia
 - D. Duration of starvation should be greater than that of patients with normal renal function
2. Regarding pre-operative preparation of patients
 - A. All transplant patients should have haemodialysis lines inserted
 - B. CRD patients have a high incidence of cardiovascular disease
 - C. Timing of pre-operative dialysis is not important
 - D. Peripheral vascular access can be sited anywhere on the limbs
3. Brachial Plexus Blockade (BPB) for vascular access surgery
 - A. BPB may cause respiratory compromise
 - B. BPB is associated with improved fistulae survival
 - C. Sedation is contra-indicated in association with BPB
 - D. BPB requires fewer pre-operative investigations
4. Features of CRD are:
 - A. Rapid gastric emptying
 - B. Autonomic neuropathy
 - C. Normal adult levels of haemoglobin
 - D. A normal immune response
5. Post-operative pain following renal transplant
 - A. Is usually severe in nature
 - B. Is most commonly managed with an epidural infusion
 - C. May be safely managed with a morphine based PCA device
 - D. Should be treated with NSAID class drugs
6. Intra-operative optimisation of the renal graft includes
 - A. Infusion of mannitol at a dose of 5 mg/kg
 - B. Increasing the warm ischaemic time
 - C. Keeping a CVP of less than 5 mmHg
 - D. Maintaining a good perfusion pressure to the graft