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Anaesthesia for Kidney Transplantation

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1. Introduction

Kidney transplantation improves the quality of life and the long-term survival of end-stage renal failure (ESRF) patients compared to those on dialysis (1). It has also been shown to be a more economic option than both haemodialysis and peritoneal dialysis (2)
With the increasing incidence of organ failure, the demand for organ transplantation has increased, resulting in longer waiting lists and increased waiting list deaths.
Recently, live organ donation has helped to relieve the shortage of deceased donor grafting. Living donor kidney transplantation offers recipients the best hope for long-term rehabilitation and its advantages are indisputable.
This chapter looks at the anaesthetic principles and management of kidney transplantation, the most frequently performed organ transplantation.

2. Preoperative assessment

Hypertension and diabetes mellitus (DM) are the two most common causes of ESRF
Hypertension should be assessed thoroughly in terms of severity, antihypertensive medications and cardiovascular complications. Hypertension associated with renal failure is usually treated with ACE inhibitors or angiotensin II receptors antagonists. (3)
A target blood pressure of 140/90 or less is usually associated with decreased incidence of left ventricular hypertrophy. (4)
Type 1 DM is usually associated with impaired renal function and can lead to the development of severe nephropathy and ESRF. Diabetic patients have increased cardiovascular risk of peripheral vascular disease. (5)
There are few other medical problems associated with advanced kidney diseases, such as:

- Endocrine abnormalities such as hyperparathyroidism
- increased calcium and phosphate serum levels.
- Dyslipidaemia
- Autoimmune diseases as vasculitis – Systemic Lupus Erythematosus (SLE)

3. Medical history

The preoperative visit plays an important role to alleviate patient's anxiety, especially for patients who have been suffering from a life-long kidney problem and anticipating to undergo a procedure that would change their life style completely.

The importance of such a visit to the anaesthetist cannot be over-emphasised, many of these patients have had general anaesthesia in the past, so useful information may be found from previous anaesthesia charts.

The aetiology of a failing kidney cannot be clearly identified every time, but it is important to be aware of the cause if this has been identified, as this may have other implications to the anaesthetic management. The associated morbidity, whether it is the cause of the renal failure or as a consequence of it, has to be sought very clearly.

The duration of renal failure and the requirement of any renal replacement therapy (RRT), either peritoneal dialysis (PD) or haemodialysis (HD) must also be noted. The longer the duration of renal failure, the more likely there will be implications to the anaesthetic management, for example the patient may have required numerous central venous cannulations in the past, resulting in stenosed or thrombosed central veins or they have had numerous arterio-venous (AV) fistulas which make intravenous access difficult.

It is useful to be aware of the patient's 'dry weight' as this will allow estimation of the preoperative fluid status. The frequency of dialysis per week should be asked and the last dialysis session the patient received must also be noted. Ideally this should be as close to surgery as possible. This will ensure optimised fluid balance (although the patient may be under filled after a session) and electrolyte balance, most importantly the potassium and urea levels. A higher potassium plasma concentration can be accepted in this group of patients, but always try to achieve a normal range.

If the patient is due a dialysis session or has elevated electrolyte levels and appears fluid overloaded, then this patient must undergo haemodialysis prior to general anaesthesia and surgery.

The normal daily fluid intake and daily volume of any native urine output (if present) should also be noted, this will act as a further guided to fluid management intra-operatively.

Prior to anaesthesia, the presence of any AV fistulas should be clearly marked and labelled to avoid cannulation and BP measurements.

A history of previous dialysis line or central line insertions into the internal jugular or subclavian veins should also be sought; this may have implications on the insertion of central lines for monitoring during the kidney transplantation. Long term dialysis lines or numerous central lines can cause stenosis and thrombosis of the central veins.

Exercise tolerance can give an indication of the severity of the condition and its associated problems, it is also a useful guide to the general health of the patient.

4. Examination

Routine examination includes vital signs and the state of hydration. Is the patient dry after recent dialysis or fluid overloaded?

Some patients presenting for renal transplant might have associated rare medical conditions that require thorough examination, conditions like Prune Belly syndrome and VATER association (please see later).

Particular attention should be made to the cardiovascular system, including blood pressure control and clinical signs of left ventricular hypertrophy (LVH).

Assessment of the respiratory system will determine further management of the patients following their surgery, if they have associated respiratory disease then they may require post-operative non-invasive ventilation or prolonged intubation and ventilation.

Airway assessment will determine the management of the patient's airway following induction of anaesthesia, but these patients should always be intubated and ventilated for a

renal transplant. Patients with DM may have associated difficult airways so appropriate equipment and techniques for managing the difficult airway must be available.

5. Investigations

Routine investigations such as full blood count (FBC) and kidney function particularly serum creatinine and blood urea nitrogen (BUN) and creatinine clearance.
Serum potassium should to be within the normal levels; usually less than 5.5 mmol/L. A further cycle on dialysis may be required if raised. Also note the bicarbonate and base excess.
Lots of important information can be obtained from the electrocardiogram (ECG), such as left ventricular hypertrophy, ischaemic heart disease or ECG changes associated with electrolyte imbalances, especially hyperkalaemia.
If the patient has a significant history of cardiovascular disease with associated ECG changes, then further assessment maybe required, such as an echocardiogram, radioactive isotope scan or even angiography. Patients with ESRF as a result of DM, may have undiagnosed cardiovascular disease, so particular care should be taken in these patients.
All patients undergoing renal transplant should at least have blood group and saved, blood should be made available if there is a high risk of bleeding.

6. Anaesthetic technique

Normally patients are not prescribed pre-medications prior to induction of anaesthesia, unless strongly indicated. Temazepam can be given orally 10 – 20 mg the night before and/or the morning of surgery in particularly anxious patients. Rantidine, metoclopramide or sodium citrate orally may also be given if the patient has reflux disease.
Induction of anaesthesia always takes place with the routine monitors ECG, non-invasive blood pressure and oxygen saturation monitoring. In patients with associated cardiovascular disease, invasive blood pressure monitoring should be considered, to ensure close monitoring of the blood pressure.
Haemodynamic stability should be maintained throughout the period of the operation with special attention to depressing the vasopressor response to intubation.
Fluctuations of the blood pressure should be within 20% of the baseline reading, this can be achieved by dampening surgical stimulation with the use of opioids.
Intraoperative opioids can be achieved via repeated boluses of Fentanyl or continuous infusion of Remifentanil, as target controlled infusion (TCI) between 4 to 6 ng/mL.
Atracurium (0.5 mg/Kg) is the muscle relaxant of choice in renal failure, it undergoes Hofmann degradation mainly and ester hydrolysis to a lesser extent.
Other muscle relaxants can be used, including all non-depolarizing muscle relaxants, but care must be taken with large or repeated doses as accumulation may result in a prolonged neuromuscular block.
The only depolarizing muscle relaxant in clinical use (suxamethonium) can be used as long as serum potassium levels are less than 5 mmol/L.
After induction of anaesthesia a central line should be inserted, ideally with ultrasound guidance, this allows monitoring of central venous pressure and the infusion of inotropes if necessary. The preferred site of insertion should be the internal jugular vein, be careful with the subclavian approach, particularly if on the fistula side as the vein may be arterialised and bleed profusely.

Immediately following induction of anaesthesia prophylactic dose of antibiotic should be given, this can vary depending on local protocol, commonly used are:
Amikacin 5 mg/Kg or gentamicin 3 mg/Kg
Co-amoxiclav dose 1.2 g can be given as well
Transplant surgery requires the administration of 'goodies', to reduce the incidence of organ rejection and to help functioning of the transplanted kidney. These are usually administered prior to revascularization and vary from centre to centre. Commonly used drugs are furosemide, mannitol, methylprednisolone (which should given as a slow intravenous infusion over half an hour, if given as a bolus it causes marked vasodilatation and may cause pronounced hypotension).

7. Maintenance of anaesthesia

All inhalational agents can be used safely, with the exception of enflurane (which is hardly being used in clinical practice nowadays)
Total intravenous anaesthesia (TIVA) is successfully being used with propofol and remifentanil to maintain GA.
The use of nitrous oxide is not associated with any ill effects, having said that, there is a trend among anaesthetists to avoid the use of N_2O in patients even with a normal kidney function.
The combination of Desflurane and Remifentanil infusion ensures smooth anaesthesia and a quick response to the challenging heart rate and blood pressure control throughout the procedure. This is in addition to smooth and rapid recovery.
Fentanyl can be given cautiously towards the end of the procedure in multiple small doses of 50 – 100 mcg; the total dose is titrated according to patient's response to pain while recovering from general anaesthesia.

8. Intraoperative monitors

Core Temp should ideally be measured via a nasopharyngeal probe, attention should be paid to keep the patient's temperature within the normal range. Hypothermia delays drug metabolism and is associated with increased incidence of postoperative complications namely chest infection and bleeding diathesis
Central venous pressure (CVP) alone can be a misleading guide to fluid requirements throughout the operation.
Oesophageal Doppler can be used to guide fluid management intraoperatively
Arterial blood gas testing (pH , PaO_2 , $PaCO_2$, bicarbonate, lactate, haemoglobin, potassium, sodium and blood glucose) is helpful if an arterial line has been placed, alternatively a venous sample could be used.
Serum potassium can go either way. Hypokalaemia should not be treated unless K is less than 3.0 mmol/L. Where as hyperkalaemia should be dealt with if K levels is 6.0 mmol/L or more. Calcium gluconate is the drug of choice in this case, as opposed to the traditional dextrose-insulin regimen.
Neuromuscular blockade monitor, an additional dose of muscle relaxants has to be judged carefully. Adequate reversal of the neuro-muscular function is extremely important before planning extubation at the end of the procedure.
Bi-spectral index (BIS) monitor can be used to assess depth of anaesthesia.

9. Fluid management

Transplant procedures are routinely short duration, minimal blood loss and preserved capillary permeability.

Patients undergoing renal transplant operations are usually receiving haemodialysis and their intravascular filling status should be monitored closely. The risk of hypovolaemia and under-filling can impair the perfusion to the transplanted kidney, whereas hypervolaemia from overzealous infusion of intravenous fluids can adversely affect myocardial contractility, especially for patients with pre-existing coronary artery disease (CAD) and impaired left ventricular function.

Even fluid balance and maintenance of the eu-volaemic status is strongly advisable

Type of intravenous fluid is of great importance, as the use of 0.9% sodium chloride is thought to be the standard fluid to be used in transplants patients, but the use of other crystalloid fluids such as Hartmann's solution (Lactated Ringer's) was used safely as long as serum potassium levels are monitored closely. (6)

Colloids could also be used safely in these procedures as long as its use does not exceed 15 mL/Kg.

Careful monitoring of the filling status of the patient is paramount, the use of central venous pressure (CVP) as the sole indicator or in combination with other monitors such as oesophageal doppler is advised. (7)

Immediate urine output can be seen in 90% of live kidney donation and up to 50% of cadaveric donation. Appropriate fluid management is the single most important factor to determine good urine output following the transplant.

It has been clearly demonstrated that it is more important than other pharmacological agents such as dopamine or the use of mannitol and colloids

Blood transfusion is better avoided in transplant procedures as the activation of autoimmune system may induce early rejection of the graft.

Renal failure patients are always anaemic, and it is quite safe to keep their haemoglobin levels as low as 7.0 g/dL in the perioperative period as long as continuous haemoglobin monitoring is available. It is a compromise between a low haemocrit that helps flow to the new kidney and the oxygen carrying capacity and delivery of oxygen to the tissues

10. Low Dose Dopamine (LDD)

Dopamine exerts its effect - at this low dose – mainly via peripheral dopaminergic receptors (renal) rather than its effect via the adrenergic receptors (cardiovascular) (8)

Few studies have shown that dopamine infusion at a rate of up to 2.5 mcg/Kg/min. would increase both urine output and creatinine clearance (9)

Other studies have questioned the value of dopamine infusion following graft of denervated kidney as evidenced by Doppler examination of renal blood flow (10), (11). The rational behind the use of dopamine – in the first 12 hr postoperatively - is mainly to ensure arteriolar vasodilatation and increase the renal perfusion pressure and to prevent acute tubular necrosis (ATN). There is no clear benefit from infusing or withholding dopamine, it is usually left to individual institution guidelines and protocols.

If the patient's blood pressure is thought to be high enough to grant satisfactory renal blood flow and ensure adequate reperfusion of the graft, then here is no need to initiate a dopamine infusion.

It is important to maintain adequate mean arterial pressure and central venous pressure prior to the release of the clamps once the donor kidney has been transplanted. This will ensure good blood flow to the kidney. The target values are dependant on the patient's normal mean arterial pressures.

11. Postoperative management

The postoperative fluid management is an important part of maintaining adequate renal perfusion. Various regimes are available. One commonly used is, crystalloid 50mls/hr plus previous hour's urine output. The urine output should be closely monitored and liase closely with the surgeons, especially if the patient remains anuric.
Local anaesthesia wound infiltration with L-Bupivacaine (2 mg/Kg) by the surgeons at the end of surgery, may help reduce post-operative pain.
Fentanyl patient controlled analgesia (PCA) is the standard pain control method
Bolus dose 10 to 20 mcg with 5 minutes lock out interval and no background infusion, but if high doses of opiates are anticipated or required a background infusions can be established, with careful monitoring.
Morphine can be used for postoperative pain control following transplant procedures; care must be exercised as accumulation of its metabolite morphine-6 glucuronide (M-6-G) may occur (12)

12. Regional anaesthesia

The use of epidural for renal transplant surgery is rare and controversial; the main reason is that uraemic patients tend to have a tendency to develop coagulopathy.
Few recent studies have shown that it is a safe technique to use as long as prothrombin time (PT) is normal and the patient should have heparin-free dialysis sessions before epidural placement.
Epidural can be used as the sole anaesthetic technique or in combination with GA.
Both techniques were found to have similar encouraging results with respect to early graft function. The level of insertion is usually low thoracic to high lumbar (T12 – L1 or L1 – L2). Local anaesthetic infusion of Levo-Bupivacaine or Ropivacaine can be used safely. (13) Facilities to continuously monitor the neurological status of the patient, and to pick early signs of epidural haematoma should be readily available. (14)

13. DVT Prophylaxis

Intraoperatively TEDS elastic stockings and flowtron boots should be routinely used. Unfractionated Heparin 5000 iu twice daily subcutaneously should be prescribed post-operatively. LMWH are to be avoided, as their metabolic end products are execreted via the kidney and can adversely affect the renal function

14. Conclusion

Kidney transplantation is the only definitive modality of treating ESRF
Patients undergoing transplant procedures present many challenges to the anaesthetist.
Success of transplant is all-dependent on thorough preoperative, close intraoperative monitoring and appropriate fluid management.

The anaesthetic technique plays an important role to ensure the immediate success of the graft. (15)

15. Prune Belly syndrome

This is a congenital abnormality mostly occurring in boys, with an incidence of 1 in 30,000 live births, it is of unknown aetiology and has three characteristic features: underdevelopment of the abdominal muscles, undescended testis and abnormalities of the urinary tract (most commonly hydronephrosis and vesico-ureteric reflux). Mortality is as much as 50% before the age of 2 years, depending on the type and severity of the abnormalities. 25-30% of patients develop chronic renal failure, often requiring renal transplantation. This group of patients has several features which could pose problems for the anaesthetist, so anaesthetic management must focus on airway, pulmonary and renal systems. Micrognathia, pulmonary hypoplasia and urinary tract abnormailities should all be evasluated prior to anaesthesia.

16. VATER association

This arises from abnormalities in mesodermal differentiation and is an acronym for Vertebral abnormality, Anal atresia, Trachoe-oesophageal fistula with oEsophageal atresia and Renal dysplasia. Renal failure is a common, there is also an increased frequency of mental retardation and these patients may also have cardiac anomalies such as ASD, VSD and dextrocardia. Anaesthesia for this group of patients must focus on the cardiovascular, respiratory and renal systems.

17. Anaesthesia for Hand-assisted Laparoscopic Donor Nephrectomy

Hand-Assisted laparoscopic donor nephrectomy (HALDN) is a fairly novel technique to harvest the kidney from a live donor.
It is minimally invasive technique compared to the standard open surgical approach.
The donor is a healthy individual, who is usually related to the recipient. He/she can be either ASA grade 1 or 2 (i.e. with a mild systemic illness that does not affect his physiological reserves).
The conduct of anaesthesia in such cases is not different from any other laparoscopic procedure.
The airway should be secured with a re-enforced endotracheal tube.
Position of the patient is the lateral decubitus, with the operating table broken in the middle
The patient should be securely strapped to the table firmly in order to prevent any change to his position during the operation.
Careful positioning needs extra-padding to protect nerves and bony prominences, the upper arm has to be kept in neutral position on an arm support.

18. References

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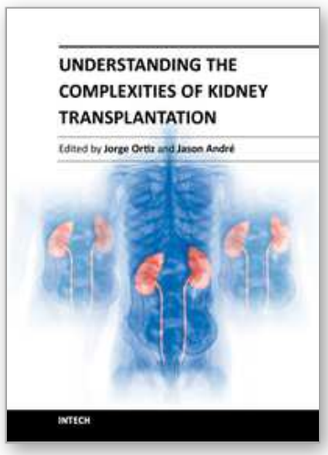

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Kidney transplantation is a complex field that incorporates several different specialties to manage the transplant patient. This book was created because of the importance of kidney transplantation. This volume focuses on the complexities of the transplant patient. In particular, there is a focus on the comorbidities and special considerations for a transplant patient and how they affect kidney transplant outcomes. Contributors to this book are from all over the world and are experts in their individual fields. They were all individually approached to add a chapter to this book and with their efforts this book was formed. Understanding the Complexities of Kidney Transplantation gives the reader an excellent foundation to build upon to truly understand kidney transplantation.

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