



Guidelines for Anesthesia for Pediatric Renal Transplantation

[Elliot Krane, M.D.](#)

Preoperative Assessment

Establish primary diagnosis.

- A. Some primary renal anomalies and diseases are associated with other syndromes of importance, such as collagen vascular disease, rheumatic heart disease, spine deformities, congenital heart disease, etc.

Establish secondary diagnoses

- A. Hypertension.
 - 1. Know the usual range of blood pressures, and the drug therapy. Continue drug therapy on day of surgery. Children on oral clonidine (Catapres[®]) should be converted to transdermal clonidine prior to surgery to prevent rebound hypertension.
 - 2. Chronic poorly controlled hypertension may be associated with hypertrophic cardiomyopathy, especially in older children and teens. Try to elicit symptoms of orthopnea and PND, especially the evening preceding hemodialysis. If present these symptoms suggest poor ventricular compliance and may indicate Swan-Ganz insertion in order to manage volume loading intraoperatively (see below).
- B. Azotemia. Severe azotemia is unusual with adequate dialysis therapy. Severe azotemia (BUN>80) may be accompanied by pleural and pericardial effusions, and platelet dysfunction that may affect anesthetic management.
- C. Electrolyte abnormality. Know the most recent Na, K, Ca, and Mg and correct if possible preoperatively. Severe hyperkalemia (K>6) should be corrected by dialysis prior to surgery.
- D. Anemia is unusual with adequate erythropoietin therapy, but still occurs occasionally. Chronic anemia is well tolerated in renal failure patients, therefore no attempt should be made to transfuse unless the Hgb<7 or the child is symptomatic.
- E. Volume status must be known. Children may be hypovolemic if recently dialyzed or hypervolemic if in need of dialysis. The child's weight is the best indicator of volume status.

Monitoring.

- A. Routine monitors include noninvasive BP, ECG, core temperature, ETCO₂, SpO₂.
- B. Invasive monitors are usually required.
 - 1. Intra-arterial monitoring is reserved for small children undergoing anastomosis of the allograft to the great vessels. Older children undergoing anastomosis to the iliac vessels do not require arterial monitoring, and in fact it should be avoided in order to preserve sites for future arteriovenous fistulae.
 - 2. CVP monitoring is required for all patients in order to guide volume management and for postoperative vascular access. Place a triple-lumen CVP line in a jugular or subclavian vein.
 - 3. Swan-Ganz monitoring of PA pressures may be necessary in the infrequent patient with symptomatic hypertensive cardiomyopathy or with echo-demonstrated cardiac dysfunction.
 - 4. All patients have bladder catheters inserted prior to surgery.
 - 5. Send labs every 1-2 hours to monitor Hct, K, acid-base status

Guidelines For Anesthesia For Pediatric Renal Transplantation

Induction of anesthesia.

- A. Routine sedative premedication is appropriate.
- B. The goal of induction of anesthesia, as for all patients, is to protect against the risk of aspiration and to minimize cardiovascular changes. The induction technique is therefore tailored to the medical conditions of the patient.

Maintenance of anesthesia.

- A. Most patients will benefit from concomitant epidural local anesthetics ± epidural opiates. Epidural catheters may be inserted before or after induction of anesthesia in the lumbar or caudal space.
- B. The following table describes the stages of surgery and the usual anesthetic maneuvers:

EVENT	DURATION	FLUIDS	DRUGS
<i>Incision, dissection of vessels, ureter, etc.</i>	2-3 hours	Insensible fluid losses + blood loss	<ul style="list-style-type: none"> • Vancomycin 12.5 mg/kg • Gentamycin 2 mg/kg • Immuran 3 mg/kg • Correct underlying, hyperkalemia, acidosis
<i>Cross clamping of vessels</i>			<ul style="list-style-type: none"> • Deepen GA • Heparin 1 mg/kg
<i>Vascular anastomoses</i>	30 minutes	Volume load with colloid, crystalloid, and blood to maintain CVP 15-20 mmHg and Hct 25-30%	<ul style="list-style-type: none"> • Lighten GA
<i>Unclamping of vessels (vein, then artery)</i>		Maintain CVP 18 mmHg	<ul style="list-style-type: none"> • Mannitol 0.25 mg/kg • Furosemide 2 mg/kg
<i>Ureteral anastomosis or implantation of graft ureter into bladder</i>	30 minutes	<p>Watch urine output on surgical field and give fluids to maintain moderate hypervolemia (CVP 10-15)</p> <p>Start CS-A if diuresis is excellent per surgeon</p>	<ul style="list-style-type: none"> • Infuse Prograf

Guidelines For Anesthesia For Pediatric Renal Transplantation

EVENT	DURATION	FLUIDS	DRUGS
Closing	30-60 minutes	Unclamp bladder drain Maintain moderate hypervolemia by matching urine output 1:1 with saline	

Fluid management:

- A. Underlying hypovolemia should be corrected if present, then fluid management should be conservative to prevent postoperative edema until you are preparing for vascular unclamping.
- B. Appropriate fluids are lactated Ringer's solution or Normosol in order not to exacerbate the usual underlying metabolic acidosis.
- C. The usual transfusion criteria may be used to guide blood replacement. In children <15 kg receiving adult grafts, usual practice is to transfuse before unclamping the vasculature.
- D. Prior to vascular unclamping the patient should be volume loaded to a CVP (or PCWP) in the 15-20 range. After unclamping there is a large drop in SVR and vascular volume and there is a potential for blood loss if the anastomoses leak. Be prepared for this. Post-unclamping graft renal function is generally best with high central pressures. Maintain the filling pressures in this target range until graft function is well established as evidenced by a brisk diuresis.
- E. After a diuresis is established it is acceptable to allow the filling pressures to drift down to the 10-15 range but not lower for the duration of the case.
- F. After the ureteral anastomosis urine production can be monitored. Replace the diuresis cc:cc with crystalloid to prevent dehydration from the urea and mannitol induced osmotic diuresis that will ensue. Urine volumes are generally quite large during this phase of surgery necessitating very large volume infusions.

Emergence and Recovery

- A. The general goal is to have older patients extubated, with BP controlled in a range approximating the donor's normal blood adult pressure (MAP 80-90), and slightly hypervolemic. Pressors (dopamine) or vasodilators (adenosine, nicardipine, nitroglycerine) should be started and titrated to the target numbers in the operating room prior to transport to the PICU.
- B. Patients <10-15kg will require postoperative mechanical ventilation for 4 reasons.
 1. Smaller kidney recipients generally require more intraoperative fluid on a ml/kg basis and the postoperative strategy includes *aggressive* hydration to diminish the incidence of ATN, even to the point of inducing pulmonary edema.
 2. The crystalloid/colloid infusions often result in pulmonary edema, which is less well tolerated by infants and children in this weight group.
 3. The implantation of a large adult kidney into the abdomen of a small child further diminishes pulmonary compliance and limits diaphragmatic mobility, leading to transient respiratory insufficiency, while decreasing SVR and leading to some degree of high output CHF.
 4. Efforts in the PICU to maintain an adult blood pressure will lead to further hypervolemia and pulmonary edema for 24-48 hours.

Guidelines For Anesthesia For Pediatric Renal Transplantation

Postoperative analgesia.

- A. If an epidural catheter is placed it should be used to provide postoperative analgesia. A local anesthetic infusion with a less lipophilic opiate is most appropriate (e.g. 1/12% bupivacaine with morphine or hydromorphone) at the usual infusion rates (e.g. 0.3 ml/kg/hr). If blood pressure is below the target range, then either use a very dilute I.a. solution or use opioid without I.a. to eliminate sympathectomy.
- B. Meperidine should not be used for postoperative analgesia because of the poor clearance of the metabolite normeperidine with renal insufficiency.
- C. Morphine infusions or PCA should be limited to a total hourly dose of 20 µg/kg in order to prevent accumulation of the 6-glucuronide metabolite which is also poorly cleared with renal insufficiency. If this infusion rate is insufficient for analgesia then an alternative opioid should be used such as hydromorphone or fentanyl.
- D. Nonsteroidal anti-inflammatory drugs (NSAIDs, ketorolac) should not be used because of the resultant diminished renal blood flow and the presence of vascular anastomoses.

Guidelines For Anesthesia For Pediatric Renal Transplantation

References

- Conzen PF, Nuscheler M, Melotte A, Verhaegen M, Leupolt T, Van Aken H, Peter K: Renal function and serum fluoride concentrations in patients with stable renal insufficiency after anesthesia with sevoflurane or enflurane. *Anesth Analg* 81:569-575, 1995
2. Takita K, Goda Y, Kemmotsu O, Mashio H, Okuyama A, Ito Y, Sakamoto H, Kawahigashi H: Secondary hyperparathyroidism shortens the action of vecuronium in patients with chronic renal failure. *Can J Anaesth* 42:395-398, 1995
3. Koehntop DE, Noormohamed SE, Fletcher CV: Effects of long-term drugs on alfentanil clearance in patients undergoing renal transplantation. *Pharmacotherapy* 14:592-599, 1994
4. Solomonson MD, Johnson ME, Ilstrup D: Risk factors in patients having surgery to create an arteriovenous fistula. *Anesth Analg* 79:694-700, 1994
5. Kellow NH: The renin-angiotensin system and angiotensin converting enzyme (ACE) inhibitors. *Anaesthesia* 49:613-622, 1994
6. Cameron EM, Lisbon A, Moorman R, Young JD: Prolonged neuromuscular blockade with pipecuronium in a patient with renal insufficiency. *Eur J Anaesthesiol* 11:237-239, 1994
7. Flechner SM: Current status of renal transplantation. Patient selection, results, and immunosuppression. *Urol Clin North Am* 21:265-282, 1994
8. Hunter JM: Muscle relaxants in renal disease. *Acta Anaesthesiol Scand Suppl* 102:2-5, 1994
9. Cooper RA, Maddineni VR, Mirakhur RK, Wierda JM, Brady M, Fitzpatrick KT: Time course of neuromuscular effects and pharmacokinetics of rocuronium bromide (Org 9426) during isoflurane anaesthesia in patients with and without renal failure. *Br J Anaesth* 71:222-226, 1993
10. Beauvoir C, Peray P, Daures JP, Peschaud JL, D'Athis F: Pharmacodynamics of vecuronium in patients with and without renal failure: a meta-analysis. *Can J Anaesth* 40:696-702, 1993
11. Arora P, Kohli HS, Kher V, Gupta A, Mishra V, Sharma RK, Kumar P: Prolonged peritoneal dialysis in acute renal failure using Tenckhoff catheter. *Indian Pediatr* 30:981-985, 1993
12. Tobias JD: Anaesthetic implications of cystinosis. *Can J Anaesth* 40:518-520, 1993
13. Hanna MH, D'Costa F, Peat SJ, Fung C, Venkat N, Zilkha TR, Davies S: Morphine-6-glucuronide disposition in renal impairment. *Br J Anaesth* 70:511-514, 1993
14. Nathan N, Debord J, Narcisse F, Dupuis JL, Lagarde M, Benevent D, Lachatre G, Feiss P: Pharmacokinetics of propofol and its conjugates after continuous infusion in normal and in renal failure patients: a preliminary study. *Acta Anaesthesiol Belg* 44:77-85, 1993
15. Hall SM: Anesthesia and ventilation for the uremic child. *Pediatr Nephrol* 5:727-732, 1991
16. Faulds D, Clissold SP: Doxacurium. A review of its pharmacology and clinical potential in anaesthesia. *Drugs* 42:673-689, 1991

Guidelines For Anesthesia For Pediatric Renal Transplantation

17. Cook DR, Freeman JA, Lai AA, Robertson KA, Kang Y, Stiller RL, Aggarwal S, Abou-Donia MM, Welch RM: Pharmacokinetics and pharmacodynamics of doxacurium in normal patients and in those with hepatic or renal failure. *Anesth Analg* 72:145-150, 1991
19. Bower S, Sear JW: Disposition of alfentanil in patients receiving a renal transplant. *J Pharm Pharmacol* 41:654-657, 1989
20. Sear JW: Sufentanil disposition in patients undergoing renal transplantation: influence of choice of kinetic model. *Br J Anaesth* 63:60-67, 1989
21. Mouquet C, Bitker MO, Bailliart O, Rottembourg J, Clergue F, Montejo LS, Martineaud JP, Viars P: Anesthesia for creation of a forearm fistula in patients with endstage renal failure. *Anesthesiology* 70:909-914, 1989
22. Grejda S, Ellis K, Arino P: Paraplegia following spinal anesthesia in a patient with chronic renal failure. *Reg Anesth* 14:155-157, 1989
23. Caldwell JE, Canfell PC, Castagnoli KP, Lynam DP, Fahey MR, Fisher DM, Miller RD: The influence of renal failure on the pharmacokinetics and duration of action of pipecuronium bromide in patients anesthetized with halothane and nitrous oxide. *Anesthesiology* 70:7-12, 1989
24. Sear JW, Hand CW, Moore RA, McQuay HJ: Studies on morphine disposition: influence of renal failure on the kinetics of morphine and its metabolites. *Br J Anaesth* 62:28-32, 1989
25. Gambling DR, Birmingham CL, Jenkins LC: Magnesium and the anaesthetist. *Can J Anaesth* 35:644-654, 1988
26. Lynam DP, Cronnelly R, Castagnoli KP, Canfell PC, Caldwell J, Arden J, Miller RD: The pharmacodynamics and pharmacokinetics of vecuronium in patients anesthetized with isoflurane with normal renal function or with renal failure. *Anesthesiology* 69:227-231, 1988
27. Orko R, Heino A, Bjorksten F, Scheinin B, Rosenberg PH: Comparison of atracurium and vecuronium in anaesthesia for renal transplantation. *Acta Anaesthesiol Scand* 31:450-453, 1987
28. Chauvin M, Sandouk P, Scherrmann JM, Farinotti R, Strumza P, Duvaldestin P: Morphine pharmacokinetics in renal failure. *Anesthesiology* 66:327-331, 1987
29. Johnson GD, Rosales JK: The haemolytic uraemic syndrome and anaesthesia. *Can J Anaesth* 34:196-199, 1987
30. Chauvin M, Lebrault C, Levron JC, Duvaldestin P: Pharmacokinetics of alfentanil in chronic renal failure. *Anesth Analg* 66:53-56, 1987
31. Linke CL: Anesthesia considerations for renal transplantation. *Contemp Anesth Pract* 10:183-231, 1987
32. Heino A, Orko R, Rosenberg PH: Anaesthesiological complications in renal transplantation: a retrospective study of 500 transplantations. *Acta Anaesthesiol Scand* 30:574-580, 1986

© 1998, 2001 by Elliot Krane. This may not be reproduced in whole or part without permission from the author.
