



**Pediatric Anesthesia
& Pain Management**

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Guidelines for Anesthesia for Pediatric Renal Transplantation

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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

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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

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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.

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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.

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