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CHAPTER 12.6

Pediatric Urology

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Kidney and Upper Urinary Tract Operations

Surgical Considerations

Description: With the increase in perinatal ultrasonographic detection of renal masses and hydronephrosis, the number of pediatric kidney and upper urinary tract surgeries has increased significantly in the past two decades. Children come to surgery at an earlier age, leading to a lower incidence of renal dysfunction.

Nephrectomy: Although the main indications for nephrectomy in adults are renal-cell carcinoma or benign renal tumors, most nephrectomies in children (with the exception of Wilms' tumors) are performed to remove poorly or nonfunctioning kidneys secondary to congenital anomalies such as obstruction or end-stage reflux nephropathy. Multicystic dysplastic kidneys (MCDK) were removed in the past, but currently are only removed if they become symptomatic or increase in size. In contrast with adults, almost all children can have good exposure for a nephrectomy through a subcostal incision rather than an intercostal or rib incision. As in the adult population, laparoscopic nephrectomy and renal surgery are becoming more common.

When a flank/subcostal incision is used, careful positioning of the patient is crucial. Failure to properly stabilize and secure the patient to the OR table can cause devastating consequences; therefore, efforts must be coordinated to properly position the patient. A rolled sheet or gel pad should be positioned beneath the dependent axilla, elevating the thorax to avoid brachial plexus neurapraxia. The dependent lower extremity is flexed at the hip and knee, while the overlying leg is kept straight. Padding is placed between the knees. In older children, in this lateral flank position, the kidney rest at the break of the table may be elevated to increase the distance between the rib and iliac crest, thus increasing exposure of the kidney. After the patient is positioned, a transverse incision is made below the 12th rib. The peritoneum is reflected, the upper ureter is dissected to the hilum, and the vessels are ligated. The kidney is excised and the wound is closed.

The lumbodorsal incision (incision parallel to the paraspinous muscle group) is performed with the patient in the prone or lateral position. This has an advantage of being a muscle-splitting, rather than a muscle-cutting incision and, as such, is associated with less postoperative pain and fewer incisional hernias. Some abdominal padding usually is added to raise the lumbodorsal area, and care should be taken to ensure complete pulmonary expansion in this position.

Most often in either the flank or lumbodorsal positioning, a urethral catheter is positioned for dependent drainage with care taken to avoid body pressure on the tubing. In this way the anesthesiologist may measure urinary output, though urinary drainage may also occur within the wound depending on the operation.

Usual preop diagnosis: MCDK; Wilms' tumor; nonfunctioning kidney; dysplastic kidney; ureteropelvic junction (UPJ) obstruction; ureterocele with loss of function.

Partial nephrectomy: Partial nephrectomies are common in children and are usually performed for a partially or nonfunctioning upper pole of a duplicated system. Ectopic ureters and ureteroceles are frequently the cause of loss of function. Again, these can be approached through either a lumbodorsal or flank incision. If the upper pole is obstructed but functional, a **pyeloureterostomy** from the upper pole ureter to the pelvis of the lower pole may be performed to salvage as much functioning parenchyma as possible. A partial nephrectomy may be performed for bilateral Wilms' tumor or other renal masses through a chevron or midline incision. An increasing number of partial nephrectomies are performed in a laparoscopic fashion.

Usual preop diagnosis: Nonfunctioning upper pole of a duplex system; ureterocele; ectopic ureter; bilateral Wilms' tumor,

angiomyolipoma (more common in patients with tuberous sclerosis).

Nephroureterectomy: Nephroureterectomy often is performed for the upper pole of a duplex system which is obstructed due to an ureterocele or ectopic ureter. After the nephrectomy/partial nephrectomy is performed through a dorsal lumbotomy or flank approach, the ureter is dissected as low as possible (usually to the level of the iliac vessels). The ureteral stump is left open if there is no vesicoureteral reflux, and tied off if there is reflux. If indicated, distal ureterectomy can be performed via a second lower abdominal incision (typically a Pfannenstiel incision). If the initial incision was done in the prone position, the patient may need to be repositioned supine.

Usual preop diagnosis: Nonfunctioning upper pole of a duplex system; ureterocele; ectopic ureter

Pyeloplasty: Fetal hydronephrosis is detected in approximately 1 in every 300 pregnancies. Pyeloplasty to correct congenital obstruction of the ureteropelvic junction (UPJ) is a common pediatric surgical procedure. The hydronephrotic kidney usually is exposed through either a dorsal lumbotomy or a subcostal flank incision; therefore, the *(Print pagebreak 1323)* patient may be in a prone or modified lateral decubitus position (See details related to subcostal or lumbodorsal incision above). In most instances, the operation is performed entirely retroperitoneally with exposure of the upper ureter and renal pelvis. The abnormal UPJ usually is excised, followed by an end-to-end anastomosis (**dismembered pyeloplasty** or **Anderson-Hynes pyeloplasty**). If the renal pelvis is large and intrarenal and dependent drainage is not possible via a conventional pyeloplasty, an **ureterocalicostomy** may be performed by removing an area of thin renal parenchyma and anastomosing the ureter to a lower pole calyx. At the conclusion of the procedure, a perirenal Penrose drain typically is placed near the anastomosis, and, depending on surgeon preference, a ureteral stent or nephrostomy tube may be used. A urethral catheter may or may not be left after the procedure. Recently, more of these procedures have been performed robotically or laparoscopically.

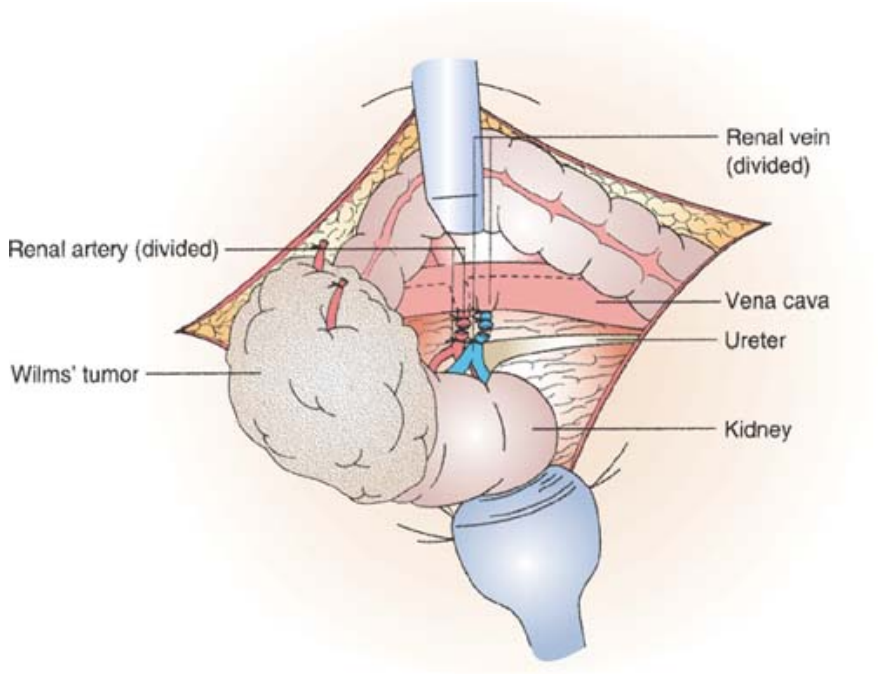

Figure 12.6-1. 1. Anatomy for nephrectomy. (Reproduced with permission from Greenfield LJ, Mulholland MW, Oldham KT, et al: *Surgery: Scientific Principles and Practice*, 3rd edition. Lippincott Williams & Wilkins, Philadelphia: 2001.)

Usual preop diagnosis: Fetal hydronephrosis 2° UPJ obstruction; hydronephrosis with a decrease in kidney function and/or flank pain

Transureteroureterostomy (TUU): This procedure, in which a ureter is anastomosed to the contralateral ureter, is used when there is problematic drainage of the distal ureter into the bladder. It is sometimes required to salvage a failed reimplantation or to transform a conduit-type diversion to an orthotopic neobladder or augmented native bladder. This technique can also be used to provide drainage in ureteral trauma. A midline or Pfannenstiel's, incision is used, and the peritoneum is entered. The ureters are dissected and the affected ureter is retroperitonealized and brought to the contralateral side anterior to the great vessels. It is anastomosed to the contralateral ureter end-to-side with absorbable suture. If required, the recipient ureter is then reimplanted into the neobladder or augmented bladder.

Usual preop diagnosis: Failed ureteral reimplant; undiversion; distal ureteral trauma

Summary of Procedures

	Nephrectomy/Pyeloplasty	Nephroureterectomy	TUU
Position	Flank/prone	Supine/flank	Supine
Incision	Dorsal lumbotomy; subcostal; flank; midline	Subcostal flank 2nd incision: Pfannenstiel	Midline or Pfannenstiel
Antibiotics	Gentamicin 1.7 mg/kg iv		
Surgical time	2.5 h	3 h (repositioning may be required)	
EBL	Minimal; if partial nephrectomy, 300 mL	Minimal	
Mortality	< 1%		
Morbidity	Bleeding: < 5% Infection: < 5% Ileus: < 5%		Urinary fistula : < 5%
Pain score	Flank: 10 Lumbotomy: 5	10	10

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Patient Population Characteristics

	Ureteroceles	MCDK*	UPJ Obstruction	Wilms' Tumor
Age range	Pediatric	Neonates	Neonates, children	Children (average, 4 yr)
Male:Female	1:4		M > F	M < F in the United States
Incidence	1:2000		1:500 birth	1:100,00
Etiology	Congenital			Genetic: WT1 gene
Associated conditions	UPJ; VUR; duplicated collecting system		VUR**; renal insufficiency	Hemihypertrophy, aniridia, HTN, Beckwith-Weidemann syndrome

*MCDK = multicystic dysplastic kidney
**VUR = vesicoureteral reflux

Suggested Readings

1. Kelalis PP, Maizels M, Das S, et al: Kidney reconstruction. In *Atlas of Pediatric Urologic Surgery.* Hinman F Jr, ed. WB Saunders, Philadelphia: 1994, 112–17, 123–43.

2. Marshall FF, Massad C, Hensle TW, et al: Kidney excision. In *Atlas of Pediatric Urologic Surgery.* Hinman F Jr, ed. WB Saunders, Philadelphia: 1994, 155–88.

3. Richey ML: Pediatric urologic oncology. In *Adult and Pediatric Urology,* Vol 3, 4th edition. Gillenwater JY, Grayhack JT, Howards SS, et al, eds. Mosby-Year Book, St. Louis: 2002, 2623–46.

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5. Shaffer BS: Pearls and perils of patient positioning. *AUA Update Series* 1995;14:178–83.

Anesthetic Considerations

Preoperative

In infants and children, most upper urinary tract surgical procedures are performed to preserve or restore renal function. Patients may present with renal function that varies from minimally abnormal, requiring little or no modification of anesthetic plan, to end-stage renal disease (ESRD) with its associated abnormalities, including hypoproteinemia, chronic anemia, and serum electrolyte disturbances. A careful preop workup is required to determine the presence or absence of abnormal physiologic factors that will affect anesthesia management. For most cases, the workup will have been performed by the patient's physicians before surgery and will provide the rationale for the surgical procedure. Such nonspecific findings as anorexia, headache, nausea, excessive tiredness, alterations in urine output, and the presence of edema will alert the clinician to the likelihood of renal failure.

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Renal abnormalities often are present as one component of a congenital malformation syndrome (e.g., polycystic kidneys, cerebrohepatorenal syndrome). In formulating the anesthetic plan, drugs eliminated by the kidney (e.g., pancuronium, meperidine, etc.) should be avoided.

Respiratory	An evaluation of pulmonary function, including auscultation of the lungs, may indicate the presence of pulmonary edema (uremic lung) or a pleural effusion. **Tests:** ABG; CXR; pulse oximetry
Cardiovascular	HTN is commonly seen in these patients, who may be taking antihypertensive medications and diuretics. In severe cases, CHF or pulmonary edema may be present, necessitating the use of cardioactive drugs and diuretics to optimize the patient's clinical condition before surgery. **Tests:** ABG; CXR; digitalis level; electrolytes
Renal	In cases requiring unilateral urinary tract surgery, the opposite kidney is usually normal. In the presence of renal insufficiency, a detailed evaluation of renal function is essential. Chronic metabolic acidosis may be present 2° poor kidney function, electrolyte abnormalities (↑ K+, ↓ Ca‡↑ or ↓ Na), hypovolemia, hypervolemia, and/or poor tissue perfusion. Children with ESRD will have been dialyzed before surgery. Preop K+< 6 mEq/L is usually safe. These patients may have an AV fistula, which must be protected during surgery (padded, no BP cuff). More commonly, a double-lumen central venous catheter will have been placed for hemodialysis (e.g., Permacath, etc). **Tests:** UA; UO; serum electrolytes; BUN; Cr; total protein; A/G ratio; ABG
Gastrointestinal	Renal failure is associated with increased incidence of delayed gastric emptying and gastroesophageal reflux. Modified rapid sequence induction should be considered.
Hematologic	Anemia, bone marrow depression, and coagulopathies are common in patients with poor renal function, particularly platelet dysfunction. An Hct of 15–18 kg/dL is not uncommon. **Tests:** Hb/Hct, PT/PTT; Plt count
Medications	Patients with ESRD will be taking many medications, which may influence the anesthetic plan. For example, chronic steroid therapy → Cushing facies, glycosuria; therefore, blood sugar and airway. Patients taking digitalis or diuretics →↓ K+→ arrhythmias. Aminoglycosides → prolongation of neuromuscular blockade. If possible, avoid renal toxic drugs in patients with

Premedication	renal insufficiency (e.g., NSAIDs, aminoglycosides, etc.). Standard pre-op medication if renal function is normal (see p. D-1). Patients with ESRD may have increased sensitivity to sedatives; doses should be titrated carefully to effect.

Intraoperative

Anesthetic technique: GETA ± epidural. (Platelet dysfunction should be assumed in ESRD and the risk/benefit of epidural placement carefully weighed). Warm OR to 70–75°F; use warming pad on OR table and forced-air warming.

Induction	Mask induction is preferable, unless iv is already in place. If an indwelling Permacath is to be accessed, heparin should be aspirated from the lumen before use. Routine use of dialysis catheters is discouraged due to need for strict sterile technique in handling of the catheter to avoid line infection. Succinylcholine should not be used in renal failure patients due to risk of K^+ release in borderline hyperkalemic patients. In the presence of renal insufficiency, antibiotics (e.g., aminoglycosides) may interfere with the metabolism of muscle relaxants and prolong their effect, and may further compromise renal function. Tracheal intubation, facilitated by a NMR (e.g., cisatracurium 0.2–0.3 mg/kg) is appropriate in patients with renal insufficiency. In appropriate patients (normal coags and no platelet dysfunction), epidural anesthesia with bupivacaine (see p. E-6) may reduce anesthetic requirements and provide postop analgesia (**NB:** local anesthetic clearance may be impaired in ESRD). Maintain muscle relaxation with cisatracurium in patients with renal insufficiency; otherwise, intermediate long-acting relaxants are appropriate (e.g., rocuronium, vecuronium, etc.).	
Maintenance	Standard pediatric maintenance (see p. D-3). Moderate hyperventilation may be beneficial (→↓ K^+ + ↑ pH).	
Emergence	Reverse neuromuscular blockade with neostigmine and atropine or glycopyrrolate (see p. D-3).	
Blood and fluid requirements	IV × 1 in upper extremities NS @ (maintenance): 4 mL/kg/h (1–10 kg) + 2 mL/kg/h (11–20 kg) + 1 mL/kg/h (> 20 kg)	Usually minimal blood loss; however, renal surgery may be associated with ↑ blood loss. Transfuse with whole blood or PRBCs as needed to maintain an adequate Hct, based on physiologic response (usually 25–30%). If K+ is high and patient has ESRD use freshest PRBC or washed PRBC to minimize the K+ load. Minimal iv flush should be administered in the presence of oliguric renal insufficiency. Fluids in excess can lead to pulmonary edema especially in an aneuric patient. Avoid K+ containing crystalloid infusions.
Monitoring	Standard monitors (see p. D-1). ± Arterial line	Place arterial line in patients with significant renal failure; serum electrolytes and ABG frequently.
Positioning	and pad pressure points. eyes.	eyes frequently if prone or flank positions are used.
Complications	Peripheral nerve injury Eye trauma Hemorrhage Dysrhythmia	

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Postoperative

Complications	Hypovolemia Anemia Hypothermia Electrolyte abnormalities Coagulopathy Metabolic/respiratory acidosis	
Pain management	Acetaminophen (see p. E-4). Narcotics by epidural catheter (see p. E-6) or PCA (see p. E-4)	In renal failure, reduce analgesic doses by 50% to minimize cumulative effects. Note: morphine-6-glucuronide is renally excreted and accumulates in patients with renal failure. It leads to increased analgesia. Morphine-3-glucuronide is antanalgesic, and likewise increases in patients with ESRD. It is therefore preferred to use Dilaudid iv for treatment of postop pain in ESRD patients.
Tests	As indicated.	

Suggested Readings

1. Berry F: Anesthesia for genitourinary surgery. In *Pediatric Anesthesia*, 3rd edition. Gregory GA, ed. Churchill Livingstone, New York: 1994.

2. Davis PJ, Hall S. Deshpande JK, et al: Anesthesia for general, urologic and plastic surgery. In *Smith's Anesthesia for Infants and Children*, 6th edition. Motoyama EK, Davis PS, eds. Mosby-Year Book, St. Louis: 1996.

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Transurethral Procedures

Surgical Considerations

Description: Transurethral procedures are not as common in children as they are in adults; however, the instrumentation, general principles, and considerations are similar. The most common pediatric endoscopic procedures are: **cystoscopy** and **vaginoscopy**, primarily as diagnostic procedures; **removal of foreign bodies** (FBs) including indwelling ureteral stents; **transurethral incision of urethral stricture**, for congenital lesions or complications of urethral surgery; **transurethral incision of posterior urethral valves** (PUV); **transurethral incision of ureterocele**; **subureteric injection for vesicoureteral reflux**; and **endoscopic injection for urinary incontinence**.

The positioning and techniques are identical to those in the adult. Careful attention to positioning is required when the pediatric patient is placed in the lithotomy position. The patient can remain supine if a flexible cystoscope is used. The most frequent neurological complication from lithotomy position may be injury to the common peroneal nerve → foot drop and sensory deficit. After the patient is positioned, a lubricated cystoscope or resectoscope (7–18 Fr) is introduced through the urethra. In infants, posterior urethral valves may be resected using a small cutting electrode or a laser, while a resectoscope is used in older children. With the advent of prenatal ultrasonography, posterior urethral valves (hydronephrosis and azotemia) often are resected in the neonatal period.

Often, transurethral procedures for urinary stone disease (**ureteral stent placement, cystolithalopaxy, ureteroscopy**) require fluoroscopy, which may bring with it both equipment considerations (fluoro-compatible moving tables) and positioning requirements to allow C-arm placement.

Foreign bodies or stones are removed using forceps, after crushing or pulverization with a laser, if necessary. Eye protection should be worn by all operating room staff if a laser is used. Occasionally, ureteral stents are placed/removed (after renal transplants, for instance) and an intraoperative retrograde pyelogram is performed to evaluate the upper tract collection system. During cystoscopy, localization of the ureteral orifices may be difficult 2° inflammation, prior bladder surgery, or congenital ectopia. The anesthesiologist may be asked to administer IV indigo carmine (this has potential effects of ↑ BP and may appear to ↓ O_2 sat), which will filter through the kidneys and produce blue urine to assist with locating the ureteral orifices.

Because most endoscopic procedures are short and the prostate and large resections are not involved, fluid absorption toxicity is rare, as opposed to that seen during "TURP syndrome." The operative team, however, must still be aware of the metabolic consequences of fluid reabsorption, as this can also occur through catastrophic ureteral or bladder perforation during endoscopic procedures in addition to the routine water reabsorption through venous channels.

By surgeon choice, lidocaine gel may be injected transurethrally at the completion of the transurethral procedure to avoid postoperative urethral irritation. Postoperatively some surgeons administer phenazopyridine (Pyridium) via nasogastric tube to decrease catheter irritation.

Usual preop diagnosis: Intravesical foreign body; bladder calculus; bladder outlet obstruction; urethral stricture; ureterocele; hematuria; urethral/vaginal mass; posterior urethral valves, urogenital sinus

Summary of Procedures

Position	Lithotomy
Incision	None
Special instrumentation	Cystoscope, resectoscope, catheters, stents, video camera unit, laser (optional)
Unique considerations	Use of cautery, fluoroscopy, PUV (prematurity or azotemia). Children with an obstructing ureterocele and pyelonephrosis may be at risk for urosepsis and should have close hemodynamic monitoring
Antibiotics	If infected urine preop, gentamicin 1.7 mg/kg iv
Surgical time	Cystoscopy: 10 min Transurethral procedure: 1 h
EBL	Minimal
Postop care	PACU; basic catheter management, with oral Pyridium in the PACU for bladder analgesia
Mortality	< 1%
Morbidity	Bleeding Urethral stricture Infection Overdistention in augmented bladder
Pain score	2

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Patient Population Characteristics

Age range	0–18 yr
Male:Female	Posterior urethral valves, strictures: male only Ureterocele 1:6 Vesicoureteral reflux 1:4
Incidence	1/1,000–1/5,000
Etiology	Posterior urethral valves; vesicoureteral reflux; intravesical FB; bladder calculus; bladder outlet obstruction; urethral stricture; ureterocele
Associated conditions	Spina bifida; paraplegia/quadriplegia; repeat cystoscopies; strictures; bladder stones; latex allergy

Anesthetic Considerations

See Anesthetic Considerations for Transurethral Procedures, Open Bladder Procedures, Penile Surgery, Genital Procedures, p. 1336.

Suggested Readings

1. Strand WR, Bloom DA: Pediatric endourology. In *Adult and Pediatric Urology,* Vol 3, 4th edition. Gillenwater JY, Grayhack JT, Howards SS, et al., eds. Mosby-Year Book, St. Louis: 2002, 2719–28.

2. Warner MA: Lower extremity neuropathies associated with lithotomy positions. *Anesthesiology* 2000; 93:938–42.

Open Bladder Operations

Surgical Considerations

Description: Open bladder operations commonly performed on children include **ureteral reimplantation** for correction of vesicoureteral reflux, obstructive megaureters, or ureterocele; **vesicostomy (Blocksom);** and **bladder neck operations.**

Ureteral reimplantation: Vesicoureteral reflux (VUR) is one of the most common abnormalities of the urinary tract in children and is present in about 25–50% of those who have UTI. Although VUR resolves spontaneously in many children, there are a number of indications for correction of VUR. These include: (a) high-grade VUR, (b) progressive VUR and renal scarring, (c) failure to resolve within several years, (d) other bladder surgery, (e) breakthrough UTIs, and (f) poor medical compliance.

Ureteral reimplantations can be performed using different approaches to the bladder (e.g., extravesical, intravesical, or a combined approach); however, these different approaches require a similar exposure and abdominal incision. In general, these are extraperitoneal rather than intraperitoneal operations. Initially, cystoscopy may be performed to *(Print pagebreak 1329)* plan a potentially complex reimplantation (e.g., duplex systems, ectopia, or periureteral diverticula). A lower abdominal suprapubic (Pfannensteil) incision (Fig. 12.6-2) is usually made, the fascia is opened and the bladder exposed. Sufficient muscle relaxation is required to enable the surgeon to place a self-retaining retractor to expose the bladder. The anesthesiologist also may be asked to limit N_2O to decrease the amount of peritoneal contents bulging toward the bladder surgical field. The bladder is then opened (intravesical approach) and the ureter(s) is (are) reimplanted, or the bladder is mobilized to expose the posterolateral ureter, which is then reimplanted (extravesical approach). When required, ureteral stents are brought to the abdominal skin through the bladder wall. A Penrose drain is typically left in place, which is either brought through the incision or through a separate skin puncture.

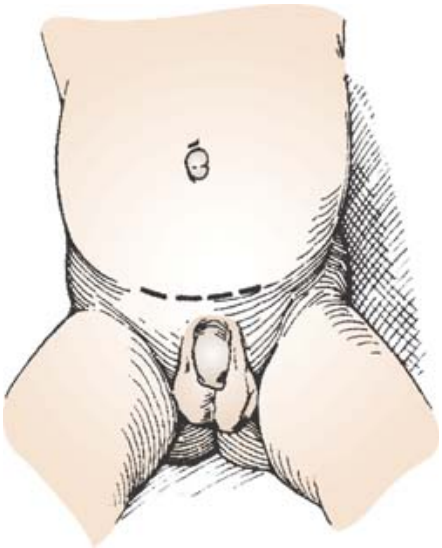

Figure 12.6-2. 2. A Pfannensteil's incision in Langer's lines is a low transverse incision that provides good access to the bladder and other pelvic organs and good cosmesis. (Reproduced with permission from Hinman F: *Atlas of Pediatric Urologic Surgery*, 2nd edition. WB Saunders, Philadelphia: 1994.)

Obstructive megaureters and ureteroceles are other conditions that may require ureteral reimplantation. The abdominal exposure and indications do not differ significantly from ureteral reimplantation for VUR; however, tailoring of the ureter by reducing its caliber and excising redundant tissue or plicating it may be necessary. A procedure on the bladder neck also may be required if an

ureterocele extends distally through the bladder outlet. Regional anesthesia techniques—specifically caudal or epidural analgesia—have gained popularity for these procedures. They have been shown to decrease postoperative pain medication requirements. Although the majority of patients void 6–9 hours after surgery, there may be ↑ risk of urinary retention after a caudal block has been administered. The surgeon's preference on whether an indwelling urethral or ureteral catheters will be left at the conclusion of the procedure should be known and discussed before consideration to giving a caudal block is entertained.

Usual preop diagnosis: VUR; obstructive megaureter; ureterocele

Vesicostomy: Infants and very young children may require bladder drainage until definitive bladder or urethral surgery. A vesicostomy may be performed, allowing the urine to flow continuously from a small, lower abdominal vesicocutaneous fistula. A 2-cm transverse incision is made halfway between the umbilicus and the pubis, and the bladder is dissected extraperitoneally to expose the dome. The bladder is opened at the dome (urachus) and is anastomosed to abdominal skin with absorbable sutures, creating a small fistula.

Usual preop diagnosis: Posterior or anterior urethral valves; severe VUR; neurovesical dysfunction; prune-belly syndrome

Bladder neck operations: These procedures usually are required in patients with severe anomalies, such as exstrophy, or severe incontinence due to an incompetent bladder neck. These are more complex procedures, with *(Print pagebreak 1330)* dissection often difficult. The approach to the bladder is similar to that of ureteral reimplantation, using a lower abdominal (Pfannenstiel) incision (Fig. 12.6-2). The Retzius space is dissected bluntly and the anterior bladder wall and pubic bone exposed. The bladder is opened and the bladder neck dissected and reconstructed. Various techniques to tubularize the anterior bladder wall, elongate the urethra, and increase the outlet resistance have been described. Bilateral ureteral reimplantation and bladder neck suspension can be performed at the same time. One special consideration is latex allergy (see Appendix G).

Usual preop diagnosis: Exstrophy/epispadias complex; spina bifida; neurogenic bladder; incontinence; bladder-neck reconstruction

Summary of Procedures

	Reimplantation	Vesicostomy	Bladder Neck
Position	Supine		
Incision	Pfannenstiel or low midline extraperitoneal		
Unique considerations	None		Latex allergy (see p. G-1)
Antibiotics	None unless indicated		Gentamicin 1.7 mg/kg iv, slowly
Surgical time	1.5 h	45 min	2 h
EBL	Minimal	→	200 mL
Postop care	PACU; ± urethral catheter ± stents. Anticholenergics for bladder spasms; belladonna and opioid suppositories, if given, must be monitored because of the potential of oversedation and respiratory depression. Older children may benefit from epidural anesthesia.	PACU	Urethral catheter 4–7 d; PACU → ward
Mortality	< 1%		
Morbidity	Infection: < 3% Bleeding: < 3% Urinary retention: Unilateral: < 5% Bilateral: 8–10% Ureteral obstruction Persistent reflux	–	< 5% Urinary retention
Pain score	7	4	7

Patient Population Characteristics

Age range	1 mo–teenage	
Male:Female	1:4	1:1
Incidence	1%	
Etiology	Unknown	Congenital
Associated conditions	UTI; renal failure	

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Anesthetic Considerations

See Anesthetic Considerations for Transurethral Procedures, Open Bladder Procedures, Penile Surgery, Genital Procedures, p. 1336.

Suggested Readings

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Bladder Augmentation

Surgical Considerations

Description: A variety of pathologies may be associated with neurogenic bladder, including spina bifida, cerebral palsy and spinal cord injury. Failure of bladder storage and/or compliance may cause urinary incontinence or high voiding pressures leading to upper tract deterioration. In such cases, and in cases where infectious or fibrotic processes have caused a reduction in bladder capacity, the patient may be a candidate for **bladder augmentation** with native intestine, colon, stomach or ureter (in the case of significantly dilated upper tracts). A **continent catheterizable stoma** may be performed at the same time due to the frequent need for catheterization subsequent to the procedure. Patients with limited mobility who require urethral catheterization can also opt for the placement of a continent catheterizable stoma using appendix or ileum. This may be done as a separate procedure with or without augmentation. These patients have often had many operations and the operative team needs to consider possible latex sensitivity (see Appendix G).

In some cases for treatment of urinary incontinence, bladder augmentation and stoma formation is combined with closure of the bladder neck or insertion of an **artificial urethral sphincter.**

Patients with neurogenic bowel may become dehydrated more easily during bowel preparation prior to surgery. Although traditionally mechanical bowel preparation for 1–2 days prior to surgery is recommended, growing evidence in the general surgery

literature suggests that bowel preparation does not reduce wound infections and anastomotic leaks and may actually increase ileus rates. Anesthesiologists should be aware of the length and extent of preop bowel preparation in case the patient has became dehydrated or suffered electrolyte imbalance due to this process. Special consideration should be made for patients who have ventriculoperitoneal (VP) shunts; typically care is made to sequester the shunt in sterile feation, keeping it away from any spillage from bowel segments.

Bladder Augmentation: Bladder augmentation is usually performed on children with a small capacity bladder, resulting from congenital abnormalities or fibrosis with resulting poor compliance. Cystoscopy may or may not be performed in association. The patient is usually in supine position and the operation may be performed through a lower midline or Pfannenstiel incision. The bowel and bladder are mobilized, with wide intraperitoneal exposure so that consideration to insensible loss may be large in small children. The relevant bowel segment is harvested, and the remaining native bowel is reanastomosed across the defect in the standard stapled or hand-sewn fashion. The “patch” of bowel segment is then sewn on to the bladder using running absorbable suture to minimize risk of subsequent nidus for bladder calculi. At the end of the procedure, a suprapubic tube is placed to decompress the bladder and allow irrigation of mucus produced by the bowel segments. Postoperatively, nasogastric decompression is maintained until return of bowel function, and perioperative antibiotics are usually continued for a minimum of 3 days.

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Usual preop diagnosis: Spinal cord injury, spina bifida, cerebral palsy; urinary incontinence; bladder tuberculosis, schistosomiasis, interstitial cystitis.

Continent catheterizable stoma (Mitrofanoff appendicovesicostomy or Monti tube): In the case of a child who needs lifetime catheterization, a continent catheterizable abdominal stoma is often preferred due to its greater ease of catheterization, particularly for children with motor impairment. Use of the appendix as a flap-valve conduit between the bladder and the abdominal wall was first described by Mitrofanoff in 1980. Operative setup is similar to that of a bladder augmentation. After amputation of the appendix, its base is brought through the abdominal wall to form a stoma at the umbilicus. The tip of the appendix is amputated to create a tube, and a small submucosal trough is made in the posterolateral bladder and an indwelling catheter is placed in the channel to maintain patency immediately postoperatively. Other continent stomas that can be catheterized may be constructed from short segments of bowel.

Usual preop diagnosis: Spina bifida, spinal cord injury or cerebral palsy with neurogenic bladder; urinary retention or urinary incontinence, limited mobility.

Summary of Procedures

	Bladder Augmentation	Continent Catheterizable Stoma
Position	Supine	
Incision	Lower midline incision	
Special instrumentation	Catheter in bladder/suprapubic tube, NG tube	Catheter in bladder/suprapubic tube, NG tube, catheter in stoma
Unique considerations	Spina bifida pts may have latex allergy	Pts with chronic catheterization may have infected urine; treat with preop antibacterial irrigation and culture specific antibiotics
Antibiotics	Broad spectrum antibiotics (e.g., 3rd generation cephalosporin)	
Surgical time	3.5 h	4.5 h (with augmentation) or 1.5 h (without augmentation)
EBL	100 cc	
Postop care	PACU – > ward	
Mortality	<1%	
Morbidity	Electrolyte abnormalities, growth retardation (>50%) Bladder calculi (10–50%) Rupture of augmented bladder (5–10%) Small bowel obstruction (3%) Bladder cancer (1%)	Stomal stenosis (30–40%)

Anesthetic Considerations

See Anesthetic Considerations for Transurethral Procedures, Open Bladder Procedures, Penile Surgery, Genital Procedures (p. 1336).

Suggested Readings

1. Adams MC, Joseph DB: Urinary tract reconstruction in children. In *Campbell-Walsh Urology*, Vol 4, 9th edition. Wein A, Kavoussi L, Novick AC, et al, eds. WB Saunders, Philadelphia: 2007.

2. Camey M, Thuroff J, Reddy P, et al: Principles of bladder substitution. In *Atlas of Urologic Surgery*, 2nd edition. Hinman F Jr ed. WB Saunders, Philadelphia: 1992, 768–82.

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(Print pagebreak 1333)

Penile Surgery

Surgical Considerations

Description: Pediatric penile operations usually correct congenital urethral abnormalities or involve circumcision. The most common surgical operation performed in the United States, **circumcision**, consists of the excision of the preputial skin to expose the glans. It can be performed for either religious, ethnic, social, or medical reasons (e.g., phimosis or recurrent balanitis).

Circumcision: Freehand circumcision involves excising preputial skin using two incisions to remove a sleeve of penile skin to fully expose the glans. At times, various clamps (Gomco, Mogen, etc.) can be used to circumcise in the newborn period. Most circumcisions performed in the operating room on older children or those with penile skin anomalies will be free-hand excisions of the foreskin. Newer considerations regarding analgesia even in the neonate recommend a penile block for this procedure. In older children being circumcised, both caudal and penile block can offer similar duration of anesthesia (4–8 h) but school-age children may, however, be bothered more by leg numbness and inability to void from the caudal block, and this should be taken into consideration.

Usual preop diagnosis: Phimosis, balanitis, family preference for circumcision

Hypospadias is the abnormal opening of the urethral meatus resulting from incomplete development of the urethra. The defect can be located anywhere from the corona of the glans to the perineum. Accordingly, surgical correction can require limited reconstruction as in the **meatal advancement granuloplasty (MAGPI)** procedure or extensive dissection and reconstruction requiring 3–4 hours of surgery. While most pediatric urologists perform one-stage reconstruction for the majority of hypospadias, some more extensive cases and surgeon choice may plan for a two-staged repair. Postoperative urethral instrumentation should be avoided because catheterization of the newly formed urethra could cause disruption of the repair. An artificial erection is obtained by infusion of normal saline into the corpora to judge need for and adequacy of repair. Significant fluid may be used and absorbed during artificial erection in the small child.

The surgeon may choose not to use a urethral catheter in distal hypospadias repairs and some midshaft repairs. In such cases, caudal anesthesia should be avoided due to risk of urinary retention and risks of surgical complications relating to need for postoperative catheterization. A **penile nerve block** may be helpful in such cases with care given to avoiding a penile hematoma or disrupting penile anatomy or blood flow to the dorsal penis. In all cases, postoperative urethral instrumentation should be avoided because catheterization of the newly formed urethra could cause disruption of the repair. Catheters, when placed, are usually secured by stitching to the glans penis. Often at the conclusion of the surgery the surgeon may require an additional 3–5 minutes of anesthesia to properly apply dressings to protect the hypospadias repair.

In reoperative cases for repair of fistulae or other complications, bladder or buccal mucosa may be needed to create a new urethra.

Use of buccal mucosa is popular but may require access to the patient's mouth and inner buccal area.

Usual preop diagnosis: Hypospadias ± chordee; fistula repair; epispadias repair; penile torsion; concealed penis

Summary of Procedures

	Circumcision	Hypospadias
Position	Supine	
Incision	Circumferential penile	+ ventral penis
Special instrumentation	None	Optical magnification
Unique considerations	1% lidocaine with 1:100,000 epinephrine for better hemostasis.	Tourniquet; injectable NS for artificial erection; 1% lidocaine. If a catheter is placed, liberal IV fluids may be given.
Antibiotics	None	
Surgical time	30 min	1.5–4 h
EBL	Minimal	< 50 mL
Postop care	Outpatient	Outpatient or ward ± urethral catheter
Mortality	< 1%	
Morbidity	Infection: 2% Hematoma: 2%	Urethrocutaneous fistula (5–20%), urethral stricture, urethral diverticulum.
Pain score	2	5

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Patient Population Characteristics

Age range	Neonates-children	> 4 mo
Incidence	61%	1:300
Etiology	Acquired	Congenital
Associated conditions	Infection	Cryptorchidism; inguinal hernia; bifid scrotum

Anesthetic Considerations

See Anesthetic Considerations for Transurethral Procedures, Open Bladder Procedures, Penile Surgery, Genital Procedures (p. 1336)

Suggested Readings

1. Elder JS: Hypospadias. In *Campbell's Urology*, Vol 3, 8th edition. Walsh PC, Retik AB, Vaughn ED, et al, eds. WB Saunders, Philadelphia: 2002, 2334–6.

2. Snodgrass W, Baskin LS: Abnormalities of the genitalia in boys and their surgical management. In *Adult and Pediatric Urology*, Vol III, 4th edition. Gillenwater JY, Grayhack JT, Howards SS, et al, eds. Mosby-Year Book, St. Louis: 2002, 2509–32.

3. Wilton NT: Postoperative pain management for pediatric urologic surgery. *Urologic Clin North Am* 1995,22(1):189–201.

4. Weksler N, Atias I, Klein M, et al: Is penile block better than caudal epidural block for post-circumcision analgesia? *J Anesth*

2005; 19(1):36–39.

Genital Procedures (Clitoroplasty, Vaginoplasty, Urethroplasty)

Surgical Considerations

Description: Masses of the introitus include urethral prolapse, prolapsed ectopic ureterocele, and rhabdomyosarcoma. Genitoplasty usually is performed in female patients with abnormal genitalia, e.g., ambiguous genitalia resulting from abnormal steroidogenesis (congenital adrenal hyperplasia [CAH], danazol exposure) and urogenital sinus or cloacal anomalies.

Urethral prolapse repair: With the patient in a lithotomy position, a simple circumferential incision is made at the junction between the prolapsed mucosa and the urethral meatus. The prolapsed tissue is excised, and anastomosis is performed with absorbable suture. Introital rhabdomyosarcoma often requires open or transurethral biopsy of the mass, and is usually treated with chemotherapy.

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Vaginoplasty/clitoroplasty: These procedures are performed in patients with ambiguous genitalia, and are usually associated with hormonal imbalance (CAH). The initial procedure usually requires reduction of the enlarged clitoris and reconstruction of the labioscrotal folds. With the patient in a lithotomy position, skin incisions are made to allow partial resection of the corporal bodies and glans with nerve sparing. Periclitoral skin flaps are used to reconstruct the clitoris and labial folds. Vaginoplasty is performed through a perineal approach by creating an urethrovaginal septum. The vagina usually can be pulled into its normal position between the urethra and rectum, and anastomosed to perineal skin flaps using absorbable sutures. Vaginoplasty can be performed with clitoroplasty in an infant. If performed later in life (puberty), a vaginoplasty with complex flaps and bowel interposition is necessary. Many of these patients are on long-term corticosteroid replacement therapy and, therefore, preop stress-dosing of steroids may be indicated; if a long, complicated intraabdominal procedure is anticipated, an abdominoperineal approach is required. A loop of sigmoid colon or ileum is isolated, along with its mesentery, and is brought through the perineal incision. It is then anastomosed proximally to the vagina and distally to skin flaps. Also, these procedures may be used for **gender reassignment** if masculinization of the ambiguous genitalia in a genotypic male is not possible.

Usual preop diagnosis: Ambiguous genitalia; CAH; cloacal exstrophy; urogenital sinus persistence; danazol exposure

Summary of Procedures

Position	Lithotomy
Incision	Perineal
Special instrumentation	Loupes
Unique considerations	Steroid replacement may be necessary (CAH)
Antibiotics	Gentamicin 1.7 mg/kg iv (children)
Surgical time	2–4 h
EBL	10–15 mL
Postop care	± Urethral catheter
Mortality	< 1%
Morbidity	Infection: < 5% Bleeding: < 5% Flap necrosis: < 5%
Pain score	6

Patient Population Characteristics

Age range	Clitoroplasty: 3–6 mo; vaginoplasty: puberty

Incidence	1:30,000 births (ambiguous genitalia)
Etiology	Congenital
Associated conditions	Hypothalamic-pituitary axis suppression; adrenal hyperplasia; steroid replacement therapy

Suggested Readings

1. Hussman D: Intersex. In *Adult and Pediatric Urology*, Vol 3, 4th edition. Gillenwater JY, Grayhack JT, Howards SS, et al, eds. Mosby-Year Book, St. Louis: 2002, 2533–64.

2. Rink R, Kaefer M: Surgical management of intersexuality, cloacal malformations, and other genitalia in girls. In *Campbell's Urology*, Vol 4, 8th edition. Walsh PC, Retik AB, Vaughn ED, et al., eds. WB Saunders, Philadelphia: 2002, 2428–68.

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Anesthetic Considerations for Transurethral Procedures, Open Bladder Procedures, Penile Surgery, Genital Procedures

Preoperative

Typically, infants and children presenting for these procedures are otherwise healthy, with some notable exceptions. **Vesicoureteral reflux** may be associated with renal dysplasia and HTN. The **prune-belly (Eagle-Barrett) syndrome** includes dystrophic abdominal musculature, requiring an evaluation of pulmonary function. **Bladder and cloacal exstrophy** may be accompanied by a spinal cord abnormality (e.g., tethered cord, spina bifida). Congenital cardiac anomalies may be present, and an evaluation should be performed prior to surgery.

Pediatric urology patients with lower urinary tract dysfunction and underlying neurologic disorders (e.g., myelomeningocele), and exstrophy are at risk for developing latex allergy as a result of repeated urethral catheterizations or surgical procedures. (See p. G-1)

Circumcision and hypospadias repair are most commonly performed in the first two years of life in otherwise healthy children.

Respiratory	Prune-belly syndrome: pulmonary function may be decreased. for Hx of respiratory compromise. Post-op ventilatory support may be necessary. adequate reversal of NMB and force of cough. **Tests:** CXR; others as indicated from H&P.
Renal	Renal anomalies may be present as part of a congenital malformation complex. **Tests:** As indicated from H&P.
Endocrine	Surgery for genital disorders usually are performed to reshape anatomic abnormalities 2° congenital endocrine disorders. Ambiguous genitalia are associated with congenital adrenal abnormalities. They are usually detected in the first month of life and may lead to severe salt-losing crises with ↑ Na^+ and ↓ K^+ The electrolyte status of these patients must be evaluated in the preop period. Treatment consists of steroid replacement. **Tests:** Electrolytes; blood sugar
Premedication	If > 7–9 months of age, consider midazolam premedication (0.5–0.75 mg/kg) po, or 1–2 mg iv (see p. D-1).

Intraoperative

Anesthetic technique: GA (ETT or LMA) using a pediatric circle. A combined technique with epidural or caudal anesthesia is often used. For small children, warm OR to 70–75°F. Use warming pad on OR table.

Induction	For patients < 5–10 yr, standard mask induction with sevoflurane/N_2O/O_2 Older patients may agree to standard iv induction, facilitated by the use of topical local anesthetic cream or patch (see p. D-1). For open-bladder and complex genital procedures, an indwelling epidural catheter for intraop and postop pain relief is recommended.	
Maintenance	Standard pediatric maintenance (see p. D-2). With epidural anesthesia, volatile and/or iv anesthetic requirements are reduced.	
Emergence	Typically, no special considerations. Carefully evaluate patient for adequate ventilation prior to extubation in those with prune-belly syndrome.	
Blood and fluid requirements	Minimal blood loss IV: 22 or 24 ga × 1 NS/LR @ (maintenance): 4 mL/kg/h (1–10 kg) + 2 mL/kg/h (11–20 kg)	Complex cases may be associated with significant blood loss, and require transform with whole blood or PRBC.
Monitoring	Standard monitors (see p. D-1). ± Arterial line	Place arterial line for measurement of arterial gases. Hct and blood glucose if significant blood loss or long case is anticipated, in patients with concurrent renal dysfunction.
Positioning	and pad pressure points. eyes.	
Complications	Nerve damage	In lower extremities, if padding is insufficient with lithotomy position.

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Postoperative

Complications	Prune belly: hypoventilation Adrenogenital syndrome: adrenal insufficiency	Assisted ventilation may be required.
Pain management	Acetaminophen Epidural (p. E-6) or PCA (p. E-4) analgesia	See p. E-4.
	IV opiates	Ditropan or ketorolac will ↓ bladder spasm. Ketorolac → renal insufficiency. Do not use if renal function is abnormal.

Suggested Readings

1. Berry F: Anesthesia for genitourinary surgery. In *Pediatric Anesthesia,* 3rd edition. Churchill Livingstone, New York: 1994.

2. Davis PJ, Hall S, Deshpande JK, Spear RM: Anesthesia for general, urologic and plastic surgery. In *Smith's Anesthesia for Infants and Children,* 6th edition. Motoyama EK, Davis PJ, eds. Mosby-Year Book, St. Louis: 1990.

3. Sheldon CA, Snyder HM III: Principles of urinary tract reconstruction. In *Adult and Pediatric Urology,* Vol 1, 3rd edition. Gillenwater JY, Grayhack JT, Howards SS, et al, eds. Mosby-Year Book, St. Louis: 1996, 249–50, 2394–5.

Inguinoscrotal Procedures

Surgical Considerations

Description: Undescended testis (cryptorchidism), hydrocele, and inguinal hernia are common in pediatric urology, and surgery is

usually performed on an outpatient basis. Testicular torsion is one of the few true pediatric urologic emergencies because testicular infarction will occur within hours of the torsion. Testicular tumors in children, accounting for 1–2% of all pediatric solid tumors, are more frequently benign than those in adults, and represent the main indication for **radical or simple orchiectomy.**

Orchiopexy: Orchiopexy for a palpable undescended testis is performed through a small inguinal incision. A nonpalpable testis may warrant diagnostic laparoscopy as the initial procedure; otherwise, the external oblique fascia is opened, exposing the inguinal canal. An initially nonpalpable testis may become palpable with anesthetic relaxation. The testis is localized and the cord is dissected to gain adequate length for scrotal fixation, without torsion or tension, to prevent postop ischemia and atrophy. If the testicle is high and adequate inguinal mobilization is not possible, dissection into the retroperitoneum may be required. The scrotal pouch is created by skin incision two-thirds the way down to the scrotum and blunt dissection between the skin and dartos muscle. The testis is fixed with suture material.

Both ilioinguinal nerve block and caudal analgesia appear to be equally effective in management of postorchiopexy pain, but parents should be counseled on the small risk of postoperative urinary retention. When inguinal block is contemplated prior to incision, this should be discussed with the surgeon. At times, inguinal infiltration distorts the anatomy and may perforate the hernia sac, thus turning a relatively simple operation into a more complex one. *(Print pagebreak 1338)* Alternatively, the block may be performed at the end of the procedure or the wound irrigated with 0.25% bupivacaine, which provides excellent postoperative analgesia and facilitates early discharge from the surgical recovery unit. (Also see Surgery for the Undescended Testicle, p. 1310.)

Usual preop diagnosis: Cryptorchidism; nonpalpable testis

Testicular torsion is a pediatric urologic emergency. There is no definitive diagnostic imaging study, although Doppler and isotope scans of the testis can be useful. At times, symptoms of testicular torsion may be indistinguishable from epididymitis or torsion of the testicular appendages (embryonic remnants). The testis is delivered through a scrotal incision, examined, detorsed, and assessed for viability. If the testis is nonviable, a **simple scrotal orchiectomy** is performed. If the testicle is viable, it is fixed in a **scrotal dartos pouch.** The contralateral testis is fixed in a similar fashion. A torsion of a testicular appendage usually is treated medically with pain control and anti-inflammatory agents. If this condition is discovered at surgical exploration, the diseased tissue is excised, the testis is simply reinserted in the scrotum, and the wound is closed. It should be noted that neonatal (antenatal) or perinatal torsion may be performed in the newborn period. It the diagnosis is unclear this operation may be performed at times through an inguinal incision.

Usual preop diagnosis: Testicular torsion; torsion of the testicular appendage

Hydrocelectomy–inguinal hernia repair: This procedure is performed through an inguinal incision and dissection of the inguinal canal. The patent processus vaginalis is carefully dissected from the cord structures; the peritoneal sac is ligated at the level of the internal inguinal ring; and the wound is closed after evacuation of the hydrocele liquid. (Also see Repair of Inguinal and Umbilical Hernias, Hydrocele, p. 1307.)

Usual preop diagnosis: Hydrocele; inguinal hernia

Radical orchiectomy: While simple orchiectomy is performed through a scrotal incision, radical orchiectomy (used when testicular cancer is suspected) is performed through an inguinal incision. The external oblique fascia is opened, and the spermatic cord is isolated and clamped at the level of the internal ring. The testis is delivered through the incision and examined. If the testis is felt to contain malignancy, the cord is ligated and divided at the level of the internal inguinal ring. If there is uncertainty in the Dx, a biopsy can be performed.

Usual preop diagnosis: Testicular mass

Summary of Procedures

	Hydrocelectomy, Hernia Repair	Orchiopexy, Orchiectomy
Position	Supine	
Incision	Inguinal/scrotal	+ Can be extended to reach retroperitoneum ± laparoscopic exploration.
Antibiotics	None	
Surgical time	1 h	
EBL	Minimal	

Postop care	PACU → home	
Mortality	< 1%	
Morbidity	Infection: 1–2% Recurrence: 1%	Testicular atrophy: 7%
Pain score	5	5

Patient Population Characteristics

Age range	1 yrs–puberty	Cryptorchidism: 1–2 yr Torsion: 0–18 yr
Incidence	1–4%	Cryptorchidism: 3% Torsion: 1:4000
Etiology	Congenital	

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Anesthetic Considerations

Preoperative

Orchiopexy, orchiectomy, hydrocelectomy, and hernia repair are performed most commonly in otherwise healthy children.

Renal	With phimosis, there may be Hx of UTIs. Possible pyelonephritis. Hematuria requires GU workup.
Laboratory	**Tests:** UA; renal function (BUN, Cr), as clinically indicated. Hct; others as indicated from H&P.
Premedication	If > 7 to 9 months of age, consider midazolam (0.5–0.75 mg/kg po) before induction. If > 10 yr old: standard premedication (see p. D-1).

Intraoperative

Anesthetic technique: GETA or LMA/mask anesthetic, using a pediatric circle with humidified and warmed gases. A combined technique with caudal anesthesia often is used for nonendoscopic procedures. For small children, warm OR to 70–75°F. Use warming pad and/or forced air warming on OR table.

Induction	In younger patients, mask induction is customary before iv placement. If the surgical procedure will be > 30 min, tracheal intubation or LMA is preferred. Intermediate-acting NMR (e.g., vecuronium 0.1 mg/kg iv or rocuronium 0.6 mg/kg iv) is administered to facilitate tracheal intubation. If appropriate, caudal anesthesia can be obtained using bupivacaine or levobupivacaine 0.125 or 0.25% with epinephrine 1:200,000; 1 mL/kg up to 10 mL total. Test dose of 1 mL should be given after a negative aspiration through the catheter or needle. A positive test dose, in contrast to adults epidural test dose, could be indicated by an increase in HR, a decrease in HR, a decrease in BP, or ST-T wave changes. The caudal local anesthetic dose should be fractionated with frequent aspirations. The addition of clonidine (1–2 mg/kg) to the caudal block intensifies and prolongs the analgesia, with minimal sedation. Acetaminophen 30–40 mg/kg PR may be given following intubation.
Maintenance	Standard pediatric maintenance (see p. D-3). If no regional block is performed, at least 2 MAC anesthesia is required prior to skin incision to prevent laryngospasm in nonintubated patients. Caudal anesthesia can be used to provide the majority of analgesia in nonendoscopic procedures.

Emergence	If neuromuscular blockade is used, reverse with neostigmine (0.07 mg/kg iv) and atropine (0.02 mg/kg iv) or glycopyrrolate (0.01 mg/kg). Extubate when patient is fully awake or deep.	
Blood and fluid requirements	Negligible blood loss IV: 20–22 ga × 1 NS/LR @ maintenance	Pediatric maintenance: 4 mL/kg/h (0–10 kg) + 2 mL/kg/h (11–20 kg) + 1 mL/kg/h (>20 kg)
Monitoring	Standard monitors (see p. D-1)	
Positioning	and pad pressure points. eyes.	Ocular compression/corneal abrasion may occur with oversized mask.
Complications	Laryngospasm	Rx: 100% O_2 jaw thrust, positive pressure. If iv is present, first deepen the level of anesthesia with propofol. If necessary, administer succinylcholine (1–2 mg/kg iv) in addition to atropine (0.02 mg/kg iv). If no iv, can give succinylcholine 3 mg/kg im, atropine 0.02 mg/kg im.
	Intravascular local anesthetic administration	Epinephrine in caudal anesthetic (to detect intravascular administration) does not significantly prolong analgesia.

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Postoperative

Complications	Bleeding	
Pain management	Caudal or regional block Acetaminophen (10–20 mg po, and 10 mg q6h pr; 30–40 mg pr on 1st dose, followed by 20 mg q 6 h prn)	Optimal analgesia and presence of parents in PACU will minimize child's agitation/movement/crying.

Suggested Readings

1. Berry FA: Anesthesia for genitourinary surgery. In *Pediatric Anesthesia,* 3rd edition, Gregory GA, ed. Churchill Livingstone, New York: 1994, 571–606.

2. Motoyama EK, Davis PS, eds: *Smith's Anesthesia for Infants and Children,* 6th edition. Mosby-Year-Book, St. Louis: 1996.

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4. Schneck FX, Bellinger MF: *Campbell's Urology,* Vol 4, 8th edition. Walsh PC, Retik AB, Vaughn ED, et al, eds. WB Saunders, Philadelphia: 2002.

5. Tobias JD: Caudal epidural block: a review of test dosing and recognition of systemic injection in children. *Anesth Analg* 200;93 (5):1156–61.

6. Wilton NT: Postoperative pain management for pediatric urologic surgery. *Urologic Clin North Am* 1995; 22(1):189–201.

Laparoscopic Procedures

Surgical Considerations

Description: Laparoscopy has become a useful technique for many pediatric urologists. It is used widely to locate the impalpable testis via **diagnostic laparoscopy**, with subsequent **laparoscopic orchidopexy** as needed, and has gained popularity for many procedures. Among them are **laparoscopic nephrectomy, partial nephrectomy, nephroureterectomy, adrenalectomy, pyeloplasty,** and **varicocelectomy.** More recently, robotic laparoscopic procedures are becoming increasingly prevalent, with **robotic pyeloplasty** and **ureteral reimplantation** being among the most common. Advantages to the use of the robot include improved 3D visualization and instrument control; however, approximately 20–45 minutes of robot set-up time should be calculated into the time under anesthesia.

As in adults, pneumoperitoneum is created by insufflating CO_2 (to a pressure of 14–16 mmHg) either through the Veress needle technique or after trocar insertion in the peritoneal cavity through a small, 1-cm periumbilical incision under direct vision **(Hasson technique)**. Other trocars (2, 5, or 10 mm) are then inserted, as necessary, under direct laparoscopic vision, avoiding abdominal wall vessels and internal organs.

Impalpable testis: If diagnostic laparoscopy reveals blind ending vessels, confirming the absence of a testis, the procedure is terminated and no inguinal incision is made. An inguinal testis remnant usually indicates either antenatal testicular ischemia or torsion. If the vessels are seen to enter the inguinal ring, the laparoscopy is ended and inguinal exploration is performed. If the testis is located intraabdominally, it is evaluated for size and location to determine whether to proceed to **orchiectomy** or a one- to two-stage (**Fowler Stevens**) **laparoscopic orchiopexy.** Laparoscopic ligation of the vessels may be done with placement of the testis into a scrotal pouch (**darto pouch**) in one stage, if adequate cord length permits. In other situations, **laparoscopic or open dissection** in the retroperitoneum may be performed. A 2nd-stage Fowler Stevens is performed after ligation of the gonadal vessels to allow adequate collateral vascular development before the intraabdominal testis is brought into the scrotum. Laparoscopic orchiectomy or **gonadectomy** also may be performed in intersex situations for a dysgenetic (streak), nonviable gonad, or for a gonad in which inadequate cord length exists.

(Print pagebreak 1341)

Usual preop diagnosis: Nonpalpable testis; cryptorchidism

Varicocele ligation: Through a transperitoneal approach identical to that of the approach for diagnostic laparoscopy, the spermatic veins are isolated from the abdominal wall and are ligated with metallic clips to reduce the varicocele. The primary complications from this procedure are hydrocele and varicocele recurrence.

Usual preop diagnosis: Varicocele

Heminephrectomy, nephroureterectomy, and pyeloplasty: With the patient in the lateral-decubitus position, the initial trocar is inserted extraperitoneally on the anterior axillary line just below the 12th rib. The prone position has also been described for a retroperitoneal approach. Gas dissection is used to open the retroperitoneal space, and kidney dissection is performed. In a nephrectomy, the hilar vessels are ligated with metallic clips. The kidney is then retrieved through the 10-mm port by morcellating it or the incision can be dilated or elongated. Laparoscopic pyeloplasty is carried out using the same principles as open pyeloplasty, namely dismembering the ureter from the renal pelvis, spatulation of the ureter, and careful reassembly of the ureteropelvic unit.

Usual preop diagnosis: UPJ obstruction; infected or nonfunctioning kidney; HTN; multicystic or dysplastic kidney; protein-losing nephropathy in ESRD

Robotic vesicoureteral reimplantation: After initial cystoscopy to determine that there is adequate size for a robotic procedure, the patient is placed in a supine position with legs splayed. A urinary catheter is placed. At that time a Hassan port is placed through a midline incision one third of the way from the umbilicus to the pubis. The bladder is cleared and a balloon trocar is placed through a cystotomy into the bladder, followed by two robotic working ports. Adequate leg padding and solid securing of the patient to the bed are necessary. The robot is then docked, coming in from the direction of the patient's feet and the patient is dropped into the Trendelenburg position, which provides improved exposure of the pelvic organs, allowing bowel to drop away. At this point either extravesical or intravesical repair may be attempted. Primary complications following robotic reimplant include bladder leak, transient obstruction and persistent reflux.

Usual preop diagnosis: Vesicoureteral reflux

Summary of Procedures

	Undescended Testis / Varicocele	Robotic Reimplant	Renal Surgery
Position	Supine; 15° Trendelenburg	Supine, legs splayed, Trendelenburg	Lateral decubitus
Incision	5–10-mm umbilical port + one or two additional ports	12-mm umbilical port and 5–8-mm working ports × 2	Four ports usually necessary
Special instrumentation	Bladder catheterization, NG tube	Cystoscopy, Bladder catheterization	
Unique considerations	Secure child firmly to avoid movement with table tilting. Intraabdominal pressure = 14–16 mmHg. Lower pressure may be needed if pulmonary mechanics are compromised. Urethral catheter commonly placed.		
Antibiotics	None	As necessary per preop urine culture	
Surgical time	30 min to 1 h	3–5 h	2.5 h (nephrectomy) to 4 h (pyeloplasty)
EBL	Minimal		
Postop care	PACU → home	PACU → ward	PACU → ward
Mortality	< 1%		
Morbidity	Overall: 0.6–5% Trocar misplacement: bowel perforation Vascular/organ thermal injury from electrocautery CO_2 embolus Grounding pad thermal injury Trocar site bleeding, trocar hernia Varicocele only: Recurrent varicocele (1–11%), hydrocele (1–5%)	bladder leak transient obstruction recurrent reflux	Bleeding < 5%
Pain score	2	4	4

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Patient Population Characteristics

Age range	10 mo–18 yr
Male:Female	Male (cryptorchidism)
Incidence	3% of newborn boys
Etiology	Congenital
Associated conditions	Renal insufficiency

Anesthetic Considerations

During mask induction care should be taken to avoid excessive positive pressure with consequent insufflation of the stomach. An OGT should be placed immediately after induction and intubation to remove air from the stomach, decreasing the risk of gastric puncture with placement of trochars, and improving surgical view during procedure. Creation of a pneumoperitoneum as part of a laparoscopic procedure impairs ventilation and can restrict venous return. The use of Trendelenburg and lithotomy positions can

further worsen the respiratory changes that occur. Anesthetic considerations for pediatric patients undergoing laparoscopic procedures are further considered in 12.5 (Anesthesia for Minimally—Invasive Surgery in Pediatric Patients, p 1313). Severely limited patient access in robotic assisted surgery makes it difficult to respond to the patient. A practice trial maneuvering the cumbersome robotic equipment should be performed to ensure rapid access to the patient in case of emergency. Care should be taken not to move operating room table after robotic arm/instruments are placed in order to avoid patient injury.

Suggested Readings

1. Farber GJ, Bloom DA: Pediatric endourology. In *Adult and Pediatric Urology,* Vol 3, 3rd edition. Gillenwater JY, Grayhack JT, Howards, SS, et al, eds. Mosby-Year Book, St. Louis: 1996, 2739–47.

2. Mariano ER, Furukawa L, Woo RK, et al: Anesthetic concerns for robot-assisted laparoscopy in an infant. *Anesth Analg* 2004;99 (6):1665–7.

3. McDougall EM, Gill IS, Clayman RV: Laparoscopic urology. In *Adult and Pediatric Urology,* Vol 1, 3rd edition. Gillenwater JY, Grayhack JT, Howards, SS, et al, eds. Mosby-Year Book, St. Louis: 1996, 829–912.

4. Peters CA: Robotically assisted surgery in pediatric urology. *Urol Clin N Am* 2007;31(4):743–752.

5. Sweeney DD, Smaldone MC, Docimio SG: Minimally invasive surgery for urologic disease in children. *Nat Clin Prac Urol* 2007;4(1):26–38.