Pediatric patients appear for surgery with a wide range of urologic conditions. For most of these children, the surgery is elective, but emergent procedures do arise (i.e. testicular torsion, relief of acute urinary obstruction). Because they are usually otherwise healthy, these patients do not require extensive medical workup. However, if the patient has other congenital anomalies besides their urologic problems or they have a syndrome, preoperative assessment must include evaluation of the associated anomalies (i.e. airway, neurologic, pulmonary, cardiac, hepatorenal, hematologic, musculoskeletal, etc.) to determine if these anomalies will impact the anesthetic technique to be utilized.

Acute or chronic renal insufficiency is part of many urologic conditions. In general, acute renal insufficiency impairs the kidney’s ability to remove or retain water, electrolytes, and products of metabolism. It is classified according to the anatomic location of the insult: pre-renal (impaired renal perfusion), renal or Intrinsic (structural damage to the renal parenchyma), or post-renal (obstruction of the lower urinary outflow tract). Intravascular and/or extravascular volume and electrolyte changes may be present and cause depletion to overload of either or both of these compartments. When renal insufficiency is suspected, laboratory tests are obtained to determine which (if any) electrolyte is abnormal. While all electrolyte concentrations can be abnormal, hyperkalemia is of particular concern because it may be life threatening. Renal insufficiency is often accompanied by acidosis. Consequently, evaluation of the patient’s acid/base status prior to surgery is important.

Patients with chronic urologic conditions have pathophysiologic issues similar to those with acute renal failure (i.e., fluid and electrolyte abnormalities, acidosis); however, other organs are more likely to be injured in patients with chronic renal failure. Where available, some patients with chronic renal failure will be on renal replacement therapy (dialysis). Many of these patients are hypovolemic immediately after being dialyzed. Consequently, it is important to determine the patient volume status prior to surgery (See Chapter 1). For elective procedures, it is better for the patient if he/she is dialyzed the day before surgery. This minimizes the likelihood of her/him being hypo or hypervolemic at the time of surgery. The latter may cause hypertension and pulmonary edema. Comparing the patient’s “dry weight” (weight when patients are not fluid overloaded) to her/his current weight will help the anesthetist determine the patient’s volume status. Additional
issues for patients on renal replacement therapy include anemia and coagulopathy. Thus, the patient’s hemoglobin level and coagulation status should be determined, when possible, prior to undertaking invasive surgical interventions. Based on the results of these tests and the likelihood of surgical hemorrhage, it may be appropriate to have suitable blood products immediately available. Systemic hypertension is also a common finding in patients with chronic renal failure, and it may be long-standing. Because the changes are chronic, it is desirable to maintain systemic blood pressure within 20% of the patient’s baseline blood pressure, even if elevated. The target blood pressure during anesthesia is relative to the patient’s elevated baseline pressure, not normotensive values for an ideal patient population. The goal is to assure sufficient blood pressure to maintain end organ perfusion (especially the brain). This is best done by maintaining the arterial pressure within the patient’s normal range.

Specific Procedures

Circumcision

For centuries circumcision has been performed for religious or cultural reasons and for medical indications. Consequently, it is one of the most widely performed surgical procedures worldwide. Cited medical benefits of circumcision include reduction in the number of urinary tract infections (UTIs), some protection against sexually transmitted diseases,\(^1,2\) a reduction in the incidence of penile cancers,\(^3\) and possibly improved hygiene.\(^4,5\) It is highly desirable to reduce the number of UTIs in infants with a congenital uropathy, including those with high-grade vesicoureteral reflux (VUR) and posterior urethral valves. The potential benefits of circumcision must be weighed against potential complications, including bleeding, infection, meatal stenosis, and complications of anesthesia.

In the United States, circumcision is usually performed by the obstetrician or pediatrician on the first or second day of life using a Gomco\(^\text{®}\) clamp or Plastibell\(^\text{®}\). Little or no anesthesia is provided. However, given recent increased awareness that newborns do in fact experience pain, many of these procedures are being performed using penile nerve blocks (Figure 14-1).
Penile nerve blocks are done after sterilizing the skin below the symphysis pubis. The needle is inserted at a 30° angle in the midline at the level of the inferior border of the symphysis pubis and advanced posteriorly. As the needle passes through superficial and Bucks fasciae, the anesthetist should feel two distinct “pops”. If the inferior border of the symphysis pubis is contacted with the needle, withdrawn it slightly and advance it slightly more inferiorly. When the needle is beyond the second “pop”, apply gentle suction to the syringe to determine that the needle is not in a vein or artery. Then inject 0.25ml/kg of 0.25% bupivacaine. Large volumes of drug may cause undue pressure on the nerves and vascular supply of the penis and injure them. e-safe-anaesthesia.org, with permission.

Patients whose circumcisions were done without anesthesia respond more to painful stimuli later in life\(^6\); therefore, some type of anesthesia should be provided for circumcision from infancy through adulthood. Spinal anesthesia has been used for circumcision, but most of them are performed under general anesthesia. Modalities used to manage post-operative pain include penile nerve blocks (See Above) or caudal epidural blocks; they are often supplemented with IV
analgesics. When it is not possible to use a regional technique, IV narcotics combined with non-steroidal analgesia may be used. Although many analgesic modalities have been employed, no one technique has been proven superior to the others. A recent Cochrane review of the data found no differences between caudal or penile blocks and parenteral analgesics alone. But the reviewers noted that good evidence is lacking, secondary to small trials and poor methodology.⁷

**Hypospadias - Chordee Repair**

*Hypospadias* is an abnormal opening of the urethra or meatus on the penis. This opening is usually on the ventral surface of the penis, but can occur on the glans, the shaft of the penis, or the scrotum or perineum. Hypospadias occurs in 0.3-to-0.7 percent in live male births⁸ and is more common in Caucasians⁹. The diagnosis is usually made during routine newborn physical examination. If he also has cryptorchidism (undescended testis), the patient may have a disorder of sexual development. A pelvic ultrasound will determine the presence of internal gonads and the possible presence of a uterus. These findings are complimented by karyotyping.

Surgical correction of hypospadias is often done in one stage; however, a series of stages, each lasting a few hours, may be required for more complicated corrections. The current recommendation of the American Academy of Pediatrics is to perform this surgery before 18 months of age, after which gender identity is defined.¹⁰,¹¹ In general, the surgery is carried out between 3 and 18 months of age. Earlier interventions (3-6 months) may be associated with improved wound healing because these children produce fewer pro-inflammatory cytokines.¹² If a second procedure is needed; it is performed after adequate wound healing has taken place.

Some anesthetists prefer general endotracheal anesthesia (GETA) rather than spinal or caudal anesthesia for these procedures, due to the young age of these patients and the length of the procedure. Because neuromuscular blockade is not necessary to facilitate surgical exposure, general anesthesia can be provided through a laryngeal mask airway (LMA). Excellent post-operative analgesia can be achieved with a caudal epidural neuraxial block (See below). Many anesthetists use 1ml/kg of 0.2% ropivacaine or 0.25% bupivacaine for these blocks. Some will add 1µg/kg of preservative-free clonidine to supplement the block or extend its duration (See Chapter 21). Placing a caudal block prior to surgical incision allows the block to be used as part of a balanced anesthetic technique. This offers a number of benefits, including need for less volatile anesthetic (which facilitates more rapid emergence from anesthesia) and for providing preemptive analgesia. Given the length of these procedures, it may be beneficial, in the author’s experience, to administer an additional one-half of the original local anesthetic dose into the caudal space at the end of surgery. For example, if 10ml of 0.2% ropivacaine were injected at the beginning of the procedure, 5ml of 0.2% ropivacaine would be injected at the end. This reduced dose of ropivacaine at the end of surgery prolongs postoperative analgesia and minimizes local anesthetic toxicity.
Wilm’s Tumor

Nephroblastoma, also known as Wilms Tumor, is the second most common solid organ tumor of childhood, after neuroblastoma. However, it is the most common primary renal malignancy of childhood. It occurs in approximately eight children per one million births and commonly presents as a unilateral lesion at 3-4 years of age. It presents at a slightly younger age when the tumor is bilateral. There is slight females predominance, with a 0.92:1 male: female ratio. The risk of developing a Wilms tumor is higher in people of African decent than in Caucasians. Those of Asian decent have the lowest incidence. Although most Wilms tumors are due to sporadic mutations, a familial relationship is present in roughly 1.5% of cases. Nearly 10% of all cases of Wilms tumor are associated with a genetic syndrome. These include WAGR (30-50% of cases), Denys-Drash (approximately 90% of cases), and Beckwith-Wiedemann (greater than 90% of cases). Mental retardation (WAGR), nephrotic syndrome (due to mesangial sclerosis and progressive renal disease, DDS), macrosomia, macroglossia, and hypoglycemia (BWS) are characteristic of these patients that are important to anesthetists.

Wilms tumors most often present as painless abdominal masses. However, anorexia, vomiting, malaise, hypertension, microscopic hematuria, and rarely an acquired von Willebrand disease type 1 (See Chapter 4) are sometimes presenting symptoms. The diagnostic work-up starts with an abdominal ultrasound (when available), followed by a Computerized Tomography scan (CT) or more commonly a Magnetic Resonance Imaging (MRI) scan when available. If these scans are not available, the diagnosis is usually made during exploratory laparotomy. A tissue biopsy is NOT obtained because this increases the risk of tumor spillage and metastasis.

In the United States, most patients undergo surgical resection of the tumor before receiving chemotherapy. Surgeons attempt to remove the tumor en bloc without rupturing the tumor capsule. To do this, a trans-peritoneal approach through a large transverse subcostal incision is used, which causes significant postoperative pain with breathing. Massive hemorrhage is possible during resection of the tumor because the tumor can extend into the renal vessels, inferior vena cava (IVC), and occasionally into the right atrium.

Chemotherapy is given preoperatively if the child has a solitary or horseshoe kidney, if the tumor is bilateral, extends into the inferior vena cava (IVC) or right atrium (RA), is considered unresectable due to its massive size, or there is respiratory distress from pulmonary metastasis. Whether external beam radiation therapy is added to the patient’s treatment depends on the cancer stage at initial diagnosis.

Some chemotherapy agent(s) used to treat these tumors will be of concern to the anesthetist. These include vincristine, doxorubicin, and dactinomycin. External beam radiation therapy may also be of concern. Known side effects of these agents include neurotoxicity (vincristine), cardiotoxicity, myocarditis, and pericarditis (doxorubicin), hepatotoxicity (dactinomycin), and
pulmonary fibrosis with scarring of the treated area (external beam radiation). The anesthetist must search carefully for signs or symptoms of these side effects. Failure to recognize them could be fatal for the patient.

Children with Wilms tumors are frequently otherwise healthy. Resection of their tumor is likely to be the first in a series of medical interventions they will experience. Therefore, premedicating them with an anxiolytic drug with amnestic properties (e.g., midazolam) may be very beneficial. General endotracheal anesthesia is preferred for maintenance of anesthesia, due to the large abdominal incision and because neuromuscular blocking agents are needed to facilitate surgical exposure. Adequate large bore intravenous (IV) access is required, given the risk of hemorrhage from tumor and/or vascular rupture. Type specific blood products should be immediately available before surgery begins. At least one large bore IV should be placed when possible in an upper extremity, since it may be necessary to cross-clamp the IVC to control hemorrhage. Intra-operative anesthetic challenges include: less than adequate pulmonary ventilation, due to increased intra-abdominal pressure; large fluid shifts between compartments (See Chapter 3) that occur with volume resuscitation and an open abdomen; massive hemorrhage; an evolving coagulopathy (See Chapter 4); major vascular injury and/or temporary IVC cross-clamping; thermoregulation; and pulmonary emboli in patients who have intravascular extension of their tumor. Post-operative analgesia can be provided with parenteral opioids, but epidural analgesia is generally favored (See Chapter 21 and below). Given the large transverse subcostal incision, epidural analgesia facilitates more normal pulmonary function, early ambulation, and the return of normal gastrointestinal function.

Neuraxial Anesthetic/Analgesic Techniques

Caudal Epidural Block

A caudal block is frequently utilized to provide analgesia for infants and children undergoing surgical intervention for urologic conditions. It is usually used as an adjunct to general anesthesia. Neuraxial blocks allow the use of less inhaled anesthetic during the procedure. In addition, it reduces or eliminates the need for intravenous opioid administration in the perioperative period, which facilitates rapid emergence from anesthesia and reduces/avoids opioid side effects, including nausea, vomiting, ileus, and pruritus.

A caudal block is performed with the infant or child in the lateral decubitus position; both thighs and knees are flexed. The anatomic landmark is the sacral hiatus; a “recess” located between the 5th sacral cornua (Figure 14-2, 14-3). These cornua are palpated as two bony prominences that are about 0.5 cm apart and are located cephalad to the intergluteal fold (crease of the buttocks).
Figure 14-2: Sacral Anatomy of Young Children

Dorsal Pediatric Sacrum

This figure shows the bony anatomy of the sacrum. A caudal epidural is done by inserting a needle or catheter in the midline at the inferior level of the sacral cornua. See text.
Figure 14-3: Caudal Block in a Child

Caudal block being performed in a child. A 22 gauge intravenous catheter is inserted into the caudal space after the back is sterilized. Once the needle tip has entered the space, the catheter is advanced off of the needle and the needle is withdrawn. This reduces the risk of entering the subarachnoid space. The catheter can be connected to sterile tubing for repeated injection of local anesthetic during and after surgery (See below). Photograph courtesy of Maurice Zwass, MD

If it is difficult to identify the cornua, the coccyx is palpated and a finger is slid cephalad to the “recess”. A 22-gauge short beveled needle or angiocatheter is inserted into the sacral hiatus (recess between the cornua) at a 45° angle. A “pop” is felt as the needle pierces the sacrococcygeal ligament. The “pop” is more easily felt with a short-beveled needle. With the needle in the caudal epidural space, the needle angle is decreased from 45°-to-0° (parallel to the long axis of the spinal canal). (IV catheters can be advanced to their hub.) The needle is then advanced only a few millimeters because the dural sac extends lower in infants (L2 or L3) than in adults (L1) (See Chapter 10); the dural sac can easily be entered if a needle is advanced too far cephalad. The needle or catheter now rests in the caudal canal, which is continuous with the epidural space in patients less than 5-6 years of age. The needle or catheter is aspirated to confirm the absence of blood and/or cerebrospinal fluid (CSF). Local anesthetic and any adjuncts being used are injected in increments with aspiration tests preceding each incremental injection.

The optimal dose and volume of drug to give in the caudal space has been studied extensively. Takasaki and colleagues\(^{17}\) published an often-cited formula that determines the volume of drug needed to achieve the desired level (by dermatome) of blockade.
**Volume of local anesthetic (ml) = 0.05ml/kg/dermatome to be blocked**

Another technique described by Armitage involves giving: 0.5ml/kg for lumbosacral level blocks, 1ml/kg for thoracolumbar level blocks, and 1.25ml/kg for mid thoracic level blocks. Bupivacaine 0.25% (maximum volume 20ml) is the drug most often used. Volume of drug injected affects the level of blockade; drug concentration affects density of the block. It is important not to exceed 3mg/kg of either ropivacaine or bupivacaine to avoid causing local anesthetic toxicity. Lower drug doses are recommended in infants less than six months of age because they have less alpha-1-glycoprotein. This increases the plasma concentrations of free local anesthetic and increases the likelihood of exceeding toxic drug levels.

Adjuvant medications are often injected along with the local anesthetic to extend or supplement the blockade. These include fentanyl 1-2µg/kg, preservative free morphine 30-70µg/kg, epinephrine (1:200,000), and/or preservative free clonidine 0.5-1µg/kg. The lower dose of local anesthetic is selected when the desired level of analgesia is below the umbilicus; the higher dose is selected when analgesia is required above the umbilicus.

When the surgical procedure last longer than 3-4 hours, the block can be “re-dosed” at the end of the procedure. To allow repeated dosing of local anesthetic during and after surgery, an IV catheter can be inserted, left in place, connected to sterile tubing, and secured in-situ with a clear adhesive dressing. At the author’s institution, it is common practice to re-dose the caudal with one half the initial volume of drug approximately 2.5 - 3 hours after giving the initial dose of drug (see above). If a medication infusion pump designed for neuraxial use is available, continuous drug infusion, 0.2-0.4mg/kg/hr. of a 0.1% - 0.2% solution of ropivicaine or bupivacaine can be used. The drug dose is reduced by 30% for <6-month-old infants.

**Spinal Block**

*Spinal* (intrathecal) anesthesia has been used in children for nearly a century (See Chapter 21) and is often the only anesthetic needed for many urologic procedures. Spinal anesthesia is particularly useful for repairing inguinal hernias in premature neonates because it reduces post anesthetic apnea in these patients. While this is true, it is still advisable to observe these patients overnight in a monitored in-patient unit regardless of the anesthetic technique used. Some of them develop postoperative apnea no matter what anesthetic is used. Another advantage of spinal anesthesia is that it that it can be used for infants who have drunk clear liquids up to two hours before surgery. To calm babies during spinal anesthesia, a pacifier dipped in a 50 percent dextrose solution (DS0) is often given to them to suck on during the procedure. The dense neuraxial blockade achieved with spinal anesthesia also appears to reduce the infant’s level of consciousness; they often fall asleep after a spinal anesthetic is placed, possibly due to decreased sensory input reaching the reticular activating system.
There are anatomic and physiologic differences in the spinal cords of infants, older children, and adults. In infants, the spinal cord (conus medullaris) ends at L3; it reaches L1, the adult level, after one year of age. Therefore, for subarachnoid block the safest needle insertion site in infants is the L4-L5 (or even L5-S1) interspace (Figure 14-4). In proportion to body weight, both the CSF volume and rate of CSF turnover are much greater in infants than in adults. Dilution of local anesthetics into this large volume of CSF explains why larger intrathecal doses of local anesthetic (mg/kg) are required to produce the desired block. The increased rate of drug turnover explains the shorter duration of subarachnoid block in infants.

**Figure 14-4: Differences in Spinal Cord Between Infants and Adults**

![Figure 14-4](http://www.joacp.org). With permission

As noted above, intrathecal dosing of local anesthetics is different for infants and adults, but the drugs used are the same. The agents most commonly used for spinal blockade in infants are bupivacaine and tetracaine. The bupivacaine dose is 0.5 -1mg/kg as an isobaric (0.5% bupivacaine) or a hyperbaric (0.75% bupivacaine in 8.25% dextrose) solution.\(^{23,24,25}\) The tetracaine dose is also 0.5 – 1mg/kg as a hyperbaric (0.5% tetracaine in 5% dextrose) solution.\(^ {26,27}\) Adding epinephrine to local anesthetics extends the block duration approximately 30%.\(^ {28}\) A technique for adding epinephrine to the local anesthetic is to fill a tuberculin syringe with epinephrine (1:1000) and then expel its contents; the residual amount of epinephrine in the syringe is sufficient to prolong the block. The higher local anesthetic dose (1mg/kg) produces motor blockade to mid-thoracic dermatome levels and may prolong the block to 1.5 hours.\(^ {29,30,31}\) Lower local anesthetic doses
(0.5 – 0.6mg/kg) are more appropriate for short duration lower extremity procedures.

Standard cardio-pulmonary patient monitoring (See Chapter 2) should always be used when placing a spinal block. Having adequate intravenous access during this time is also important. The block can be done with the child in either the sitting or lateral position. However, the CSF hydrostatic pressure in the lower back is higher in the sitting position, which increases flow of CSF through small spinal needles. Significant neck flexion is avoided to prevent causing airway obstruction, a common problem in young children. Infiltration of the skin with local anesthetic (1% lidocaine) is generally done with a 30G needle at the intended needle insertion site (midline at the L4-L5 or L5-S1 interspace). A 22G spinal needle with a stylette, is used to avoid the small risk of carrying tissue into the CSF and causing an epidermoid tumor. “Pencil point” spinal needles are available in pediatric sizes. Two tactile “pops” should be experienced, one at the ligamentum flavum and the other at the dura mater. Following the 2nd “pop”, the stylette is removed; CSF flow through the needle confirms intrathecal placement of the needle. Smaller gauge needles are available; however, free flow of CSF through them is impeded. Local anesthetic is injected slowly to avoid causing increased cephalad displacement of the drug and a “high spinal”. If an electrocautery pad is needed for surgery, it can be placed on the patient’s thigh.

**Epidural Blockade**

When innervation of the surgical incision site is from higher dermatomes (e.g., a Wilm’s tumor incision), it is advantageous to place an indwelling epidural catheter at that specific dermatome level. This allows the anesthetist to provide extended post-operative analgesia, especially when a continuous infusion of local anesthetic (often with an opioid adjunct) is used. Inserting the epidural catheter at the higher dermatome has at least two advantages: 1) less likelihood of contaminating the insertion site with stool or urine; 2), smaller volumes of local anesthetic are needed to produce anesthesia/analgesia than are needed when the drugs are given by the caudal route. The safety of placing both lumbar and thoracic epidural catheters by experienced anesthetists has been demonstrated. The technique for placing an epidural catheter for infants is similar to that for adults, but there are a few differences. In infants and children the ligamentum flavum is thinner, making it more difficult to recognize “engagement” of the epidural needle. Also, the angle of needle entry is less acute (more perpendicular) in children. The distance from the skin to the epidural space is estimated to be 1mm/kg of body weight for children between 6-months and 10-years of age. Venous air embolism has occurred during placement of an epidural block in children, probably by injecting air into an epidural vein. Therefore, it is recommended that saline (not air) be employed when using with the loss of resistance technique to identify the epidural space. Epidural catheters should be placed using equipment specific in size and caliber for infants and children. A 5cm 18G Tuohy needle, with either a 20G or 21G epidural catheter, can be used without difficulty. This shorter Tuohy needle offers better needle control during catheter placement. Epidural neuraxial blockade may be used intraoperatively with
the same advantages noted with caudal epidural block (See above). To initiate blockade, it is recommended that 0.3-0.5ml/kg of 0.1-0.25% bupivacaine (or 0.1-0.2% ropivicaine) be incrementally injected after the aspiration test is found to be negative and that this be done before each increment of drug is injected. A continuous infusion of local anesthetic 0.2-0.4mg/kg/hr. is then initiated. This dose of drug is decreased by 30% for infants <6 months of age.

References

16. Ibid.


