Chapter

34 Anaesthesia for Urological Surgery in Children*

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Introduction

Paediatric urology theatre lists comprise a range of minor through to major complex cases. The children are often well, but impaired renal function is not uncommon. In addition to routine preoperative assessment, children should have a urine culture to exclude concurrent urinary tract infection (UTI), and coordination with the surgical team will guide antibiotic prophylaxis, which will also be dependent on previous culture results and local protocol. In this chapter, we discuss the anaesthetic management of a sub-specialty that allows for a variety of general and regional anaesthetic techniques to be applied.

Minor Procedures

Common procedures include:

- Cystoscopy
- Resection of posterior urethral valves
- Circumcision
- Insertion of suprapubic (SP) lines
- Hypospadias repair
- Orchidopexy

Cystoscopy

Indications for cystoscopy vary from investigation of minor renal tract abnormalities to follow-up after reconstructive or tumour surgery. Antibiotic prophylaxis is required. A supraglottic airway device (SGA) with spontaneous ventilation is standard practice except in neonates where intubation and ventilation are usually required. Cystoscopy is stimulating; fentanyl 1–2 mcg kg^{-1} is needed after induction of anaesthesia with adequate depth of anaesthesia to avoid laryngospasm and provide postoperative analgesia. PRN paracetamol, ibuprofen (>3 months old and providing renal function is normal; or an alternative non-steroidal anti-inflammatory [NSAID]) and oral morphine 100–200 mcg kg^{-1} can be prescribed.

Resection of Posterior Urethral Valves

Posterior urethral valves (PUV) are the most common cause of urinary tract obstruction and only occur in boys. They are usually a sporadic occurrence, appearing early in fetal development with an incidence of 1:8,000. The severity of obstruction varies widely. Regardless of severity, the effects on the renal tract are lifelong. Those with minimal obstruction may not present until a later age, with recurrent UTI, enuresis or renal impairment. The bladder capacity is typically abnormal with vesico-ureteric reflux and bladder augmentation surgery (see the section 'Bladder Augmentation (Ileocystoplasty) and Mitrofanoff Formation' later in this chapter) may be required to preserve renal function. Monitoring of renal function is needed throughout life. One third of these boys will progress to end-stage renal failure. In children undergoing renal transplantation, 10–15% have a diagnosis of PUV. In the most severe cases, there is oligohydramnios, renal failure and lung hypoplasia requiring neonatal intensive care or possible incompatibility with life. Most commonly, bilateral hydronephrosis without renal impairment is detected antenatally. A cystoscopy is performed in the first few days of life to resect the PUV, with a check cystoscopy repeated one to two months later, occasionally with further resection. A circumcision can be performed at the initial PUV resection to reduce the rate of UTI. Neonatal airways are managed with tracheal intubation; larger infants undergoing a check cystoscopy can be managed with an SGA and spontaneous ventilation. The baby is positioned at the far end of the operating table in a 'natural'

* Many thanks to Dr Angus McEwan, who wrote the first edition of this book chapter, much of the content of which has been used in this revision.

lithotomy position, which may necessitate long ventilator tubing. Antibiotic prophylaxis is required. For isolated PUV resection, fentanyl 1–2 mcg kg^{-1} usually provides adequate analgesia, although some colleagues may perform caudal without additives. If circumcision is required, a caudal provides excellent analgesia. Local anaesthetic dose should be halved in neonates (e.g. maximum levobupivicaine 1 mg kg^{-1}). Oral paracetamol is prescribed postoperatively, and fluid balance monitored as a large volume of urine may be produced after relief of the bladder outlet obstruction.

Circumcision

Medical indications include phimosis, paraphimosis, balanitis, balanitis xerotica obliterans and recurrent UTI. Outside of the neonatal group, an SGA with spontaneous ventilation is used. A caudal provides optimal analgesia. Clonidine 1–2 mcg kg^{-1} can be safely used as an additive to prolong analgesia but should be avoided in neonates and ex-premature infants. A penile block can be performed when a caudal is contraindicated. Regular paracetamol, NSAIDs and PRN oral morphine are prescribed postoperatively.

Insertion of SP Lines

Suprapubic line insertion is the temporary placement of a suprapubic catheter for postprocedure urodynamic testing. It can be carried out with face mask anaesthesia, or an SGA. One mcg kg^{-1} fentanyl is useful, as bladder filling and catheter insertion are stimulating. Prophylactic antibiotics are required. Postoperatively, treatment for bladder spasm may be required with oral oxybutynin 1.25–2.5 mg every 8–12 hours whilst the catheter remains in place.

Hypospadias Repair

Hypospadias is a congenital malformation of the urethral meatus where the opening is on the ventral surface instead of the tip of the penis. It occurs in 1:250 boys. It may be associated with cryptorchidism, chordee (curvature of the penis) and other urogenital anomalies but is most often an isolated finding with normal renal function. Hypospadias can be defined as anterior (mild displacement of meatus), middle (meatus on ventral surface of penis) or posterior (meatus significantly displaced; scrotal, perineal).

Surgery takes between one and three hours, with the aim to resolve the chordee, extend the length of the urethra to create the meatus at the tip of the penis and perform circumcision. If further tissue is required, a two-stage procedure may be carried out. Posterior auricular tissue or buccal mucosa are used as grafts. For complex hypospadias, a group and screen should be performed.

Anaesthesia with an SGA and spontaneous ventilation is usual unless a buccal mucosal graft is expected. In this case, a south-facing RAE tracheal tube positioned to one side of the mouth is suitable, although some surgeons prefer nasal intubation. A throat pack should be used according to local guidelines. Caudal analgesia with clonidine is ideal for hypospadias repair, and antibiotic prophylaxis should be administered. Postoperative paracetamol, NSAIDs and PRN morphine are prescribed, and oxybutynin may be needed for bladder spasm. Minor hypospadias repair can be performed as a day-case procedure. More complex repairs require an overnight stay. All children return for a dressing change under anaesthesia the following week. There has been concern over an increased risk of urethrocutaneous fistula after hypospadias repair in boys receiving caudal anaesthesia (see 'Further Reading'). The authors' institutional practices have not currently been altered due to the lack of prospective data and local audit data suggesting no association.

Orchidopexy

Orchidopexy is performed for an undescended testis (cryptorchidism). The aim of surgery is to fix the testis in the scrotum. It is a common congenital anomaly with an incidence of 2–8% and is more common in premature infants as the normal inguino-scrotal testicular descent occurs between 25 and 35 weeks gestation. Spontaneous descent is uncommon after 1 year, and orchidopexy should be performed between 6 and 18 months old, with the aim to improve fertility and reduce the occurrence of testicular cancer (see 'Further Reading'). Examination under anaesthesia will determine if the testis is palpable in the inguinal canal. For a palpable testis, an open procedure is performed with small incisions in the groin and scrotum. For an impalpable testis, laparoscopy is needed to

identify its location, which may be 'true' in the path of descent or 'ectopic', such as in the perineal or femoral region. If the testis can be brought down to the scrotum without tension, a single-stage procedure is performed. Many intra-abdominal testes require a two-stage, or 'Fowler–Stephens', operation. This involves division of the testicular vessels, so that the blood supply to the testis is via the vas deferens. The second stage occurs six to nine months later once collateral blood supply is fully developed.

An SGA and spontaneous ventilation with a caudal are appropriate for open orchidopexy. An ilio-inguinal block with infiltration of local anaesthesia to the scrotal incision is an alternative to a caudal. Laparoscopic orchidopexy requires tracheal intubation. Antibiotics are not routinely necessary. A caudal block remains the ideal analgesia, with infiltration of local anaesthetic at the umbilical port site. Paracetamol, NSAIDs and PRN oral morphine provide adequate postoperative analgesia.

Major Procedures

Laparoscopy is frequently used for many of these procedures, and worldwide, urology has seen the greatest use of robotic surgery within paediatrics. However, only few institutions in the United Kingdom currently offer paediatric robotic surgery. All cases will require antibiotic prophylaxis.

Major urological procedures include:

- Pyeloplasty
- Ureteric re-implantation
- Nephrectomy
- Resection of Wilms' tumour (nephroblastoma)
- Bladder exstrophy and epispadias repair
- Bladder augmentation (ileocystoplasty) and formation of Mitrofanoff
- Renal transplant

Pyeloplasty

Hydronephrosis caused by pelviureteric junction (PUJ) obstruction resulting in a poorly functioning kidney, recurrent UTI or pain is managed with an open, laparoscopic or robotic-assisted pyeloplasty (RAP). Open procedures are significantly faster and cheaper than laparoscopy and RAP, but RAP has high success rates and children have significantly shorter length of stay. Complication rates do not differ, and techniques continue to vary between institutions. PUJ obstruction is quite rare (1:1,500 children), usually unilateral, and even if the kidney is poorly functioning, renal impairment is uncommon due to a normal contralateral kidney. Persistent dilatation in the postnatal period with poor function on micturating cystourethrogram is an indication for surgery in infants. Whatever the surgical technique, intubation and ventilation are needed. For open procedures in small babies, the incision is small (approximately 3 cm). A group and screen are not required. Analgesia options include local anaesthetic (LA) infiltration, transversus abdominis plane (TAP) block, or quadratrus lumborum (QL) block. A morphine NCA can be prescribed if a block is not performed, although it is not often required for more than 24 hours. Oral morphine 200 mcg kg^{-1} is adequate if the child has had a regional technique, along with simple analgesics, including NSAIDs in the presence of a normal contralateral kidney.

Ureteric Re-implantation

Ureteric re-implantation is required for significant vesico-ureteric reflux (VUR) or obstruction causing retrograde urinary flow which has not responded to less invasive endoscopic treatment, for example cystoscopy and 'Deflux' bulking injections. Untreated VUR causes recurrent UTI, renal scarring and ultimately chronic renal impairment. Surgery typically involves a small lower abdominal transverse laparotomy, although laparoscopic and robotic-assisted procedures are described. Blood loss is minimal, but a group and screen should be available. Invasive monitoring is not necessary. Surgical time is approximately two hours, and regional anaesthesia is ideal with a caudal block or epidural. Postoperative bladder spasms are treated with oral oxybutynin and diazepam, but a continuous caudal or lumbar epidural infusion manages bladder spasms most effectively unless contraindicated.

Nephrectomy

Nephrectomy and heminephrectomy are required for a complete or partial non-functioning kidney respectively, severe hydronephrosis or nephroblastoma (which is discussed separately in the next section). Surgery is usually laparoscopic or robotic assisted. A group and screen should be available for a benign laparoscopic nephrectomy. One unit of blood should be cross-matched for open or heminephrectomy and four units for a transplant

nephrectomy. Invasive monitoring is not routinely required. Positioning is either prone or lateral, with usual precautions for prone positioning necessary. As with pyeloplasty, LA infiltration, TAP or QL block are useful for laparoscopic or robotic-assisted nephrectomy. If an open nephrectomy is planned or conversion required, an epidural, TAP/QL block or morphine NCA/ PCA can be used.

Wilms Tumour (Nephroblastoma)

Wilms tumours account for 90% of renal tumours in children and around 5% of all childhood malignancy. Long-term prognosis is good, with >90% five-year survival. However, morbidity is high, with significant chemoradiotherapy-related side effects such as cardiotoxicity, ototoxicity, peripheral neuropathy, scoliosis, infertility and secondary malignancy. Wilms tumour is associated with specific syndromes relating to WT1 gene mutation, including WAGR (Wilms, aniridia, genito-urinary malformation, developmental delay) and Denys–Drash (Wilms, nephrotic syndrome, male pseudohermaphroditism). Multiple other syndromes have been associated with Wilms, including Beckwith–Wiedemann, trisomy 18 and neurofibromatosis-1. Children usually present under the age of five years with an abdominal mass. Late presentation may be with fever and weight loss or abdominal pain and haematuria if the tumour bleeds or extends into the renal pelvis or ureter. Tumour extension into the inferior vena cava (IVC) and right atrium (RA) occurs in 4% and 1% of cases respectively. Metastases occur in the lungs and lymph nodes, less commonly the liver. Paraneoplastic syndrome can result in hypertension (50% cases), hypercalcaemia or acquired von Willebrand disease and coagulopathy. Imaging with ultrasound, CT and MRI aids staging and surgical planning. Chest X-ray and tumour biopsy determine histology and spread. Bilateral nephroblastoma occurs in 5% of cases, more commonly in girls. Neoadjuvant chemotherapy reduces tumour size and vascularity but is not used in all treatment regimens. Cardiopulmonary bypass is required as a joint procedure with cardiothoracic surgeons if the tumour remains in the IVC/RA after chemotherapy. Postoperative chemotherapy is usually needed to treat residual disease, and around 20% of children will require additional radiotherapy. Full blood count, coagulation and renal function should be checked preoperatively. Antihypertensive medication should be continued perioperatively, other than angiotensin converting enzyme (ACE) inhibitors, which should be omitted on the morning of surgery. Hypertension often resolves after nephrectomy. Children who have had preoperative chemotherapy will have central venous access, which can be used for induction of anaesthesia and for invasive monitoring along with an arterial line. If no central access is present, it should be obtained, as well as large-bore peripheral venous access. All lines should be in the upper body, as on occasion the IVC must be clamped during surgery. Compression or kinking of the IVC during tumour resection or, less commonly, major haemorrhage result in haemodynamic instability. One unit of blood should be cross-matched. Large tumours cause atelectasis and reduced functional residual capacity but also delayed gastric emptying, which should be taken into consideration when planning induction of anaesthesia. It should be anticipated that syndromic patients, e.g. Beckwith–Wiedemann or trisomy 18, may have a difficult airway. A cuffed tracheal tube is recommended, as ventilation may be difficult during surgery due to increased intra-abdominal pressure, particularly with very large tumours and surgical retraction. Children with pre-existing hypertension should be expected to have labile blood pressure on induction and intubation and should therefore be well hydrated before anaesthesia. Tumour resection has classically been via a large transverse abdominal incision, with considerable third space and evaporative fluid losses. A low thoracic (T9–10) epidural is ideal for intra- and postoperative analgesia. Temperature maintenance is important, requiring fluid and forced-air warmers. Postoperative intensive care is not routinely necessary. For small tumours, laparoscopic resection of Wilms tumour has similar oncological results and reduces long-term morbidity from adhesion-related complications and scarring. Robotic-assisted laparoscopic resection of Wilms tumours have been reported in small numbers with favourable outcomes, although operative time and cost are a consideration.

Bladder Exstrophy and Epispadias Repair

This is a rare congenital anomaly (1:40,000) where the skin over the bladder develops abnormally, resulting in exposure of the bladder on the anterior

abdominal wall. Midline structures fail to fuse; the pelvis is splayed, and the urethra does not develop normally (epispadias). Epispadias can also occur in isolation. Cryptorchidism is typical in boys with bladder exstrophy. Cloacal exstrophy with rectal exposure and associated exomphalos is rarer. Spinal abnormalities such as myelomeningocele or sacral agenesis with spinal cord tethering may be present in cloacal exstrophy. Repair of a myelomeningocele should take precedence over bladder closure, and babies with cloacal exstrophy will also require colostomy formation. Diagnosis is often antenatal and transfer to a specialist centre should occur as soon as possible after birth. The defect is covered with a thin plastic film to prevent fluid and heat loss and minimise infection risk. Surgical closure should occur within the first 48 hours of life. Delayed closure results in a hyperaemic and oedematous bladder, increasing the risk of infection, and renal damage may occur with ureteric obstruction. The risk of bladder carcinoma in later life is also increased. The surgical approach to repair a bladder exstrophy is either 'complete' or 'staged' and varies between centres. The overall aim of surgery is to achieve continence through bladder closure, pelvic opposition and epispadias repair. Complete repair takes three to four hours, involving considerable blood and fluid loss, and does not preclude the need for further surgery. A staged approach requires simple bladder closure and abdominal wall repair within 48 hours of birth, which takes approximately 90–120 minutes, with minimal blood loss. A hip spica may be applied to oppose the pelvis. A Kelly procedure or bladder neck reconstruction and epispadias repair at one to two years of age creates a sphincter with the aim to allow the bladder to hold urine and increase capacity. Bladder augmentation may be required in later years (see the following section). Renal function should be checked and antibiotic prophylaxis administered. All considerations relevant to neonatal anaesthesia apply. Babies should be intubated and have good IV access ideally in the upper limbs. If adequate peripheral access is not possible, central access which avoids the femoral veins due to surgical proximity may be necessary. Fluids should be warmed, and a unit of blood that is likely to be needed should be cross-matched. For a complete repair, an arterial line should be placed due to the risk of haemodynamic instability and major haemorrhage. For simple bladder closure, analgesia is ideally provided with a lumbar epidural to avoid postoperative ventilation. If a sacral pit is present, it is advisable to exclude spinal abnormalities preoperatively using ultrasound. An epidural is contraindicated in cloacal exstrophy due to the associated spinal anomalies. If an epidural is contraindicated or not possible to site, high-dose opiates and postoperative ventilation are required. Some surgeons prefer babies to remain ventilated for a short period postoperatively to reduce the risk of wound dehiscence.

Bladder Augmentation (Ileocystoplasty) and Mitrofanoff Formation

The aim of a cystoplasty is to increase bladder capacity, reduce urinary tract infection, achieve continence and preserve renal function. Children with bladder or cloacal exstrophy, posterior urethral valves, spina bifida or anorectal anomalies who have not responded to intermittent catheterisation or bladder neck Botox injections may be offered augmentation. A Mitrofanoff stoma is constructed for lifelong intermittent catheterisation. Those with a neuropathic bladder may also have severe constipation and benefit from an antegrade continence enema (ACE) stoma at the same operation. The surgery involves a segment of ileum being anastomosed to the superior aspect of the bladder to increase capacity (ileocystoplasty), and the appendix is anastomosed between the bladder and abdominal wall, producing a stoma which will not leak urine (Mitrofanoff). Bowel preparation is required preoperatively with 48 hours of clear fluids. Renal function and electrolytes should be checked and one unit of blood cross-matched. This group of children will have had multiple operations and may have perioperative anxiety necessitating premedication or play specialist and psychology input. They are at risk of latex allergy due to long-term intermittent catheterisation. Surgical approach is classically via a laparotomy, although there are case reports and series of children undergoing laparoscopic and robotic-assisted bladder augmentation. Surgery is prolonged, taking four to six hours. Standard anaesthetic considerations for a laparotomy are required with antibiotic prophylaxis and appropriate vascular access for potential blood and fluid replacement. A low thoracic epidural is ideal for open procedures unless contraindicated.

Chronic Kidney Disease and Renal Transplantation

Aetiology of chronic kidney disease (CKD) in children varies with age. Under the age of six, congenital abnormalities or hereditary conditions predominate, such as obstructive uropathy, renal dysplasia, polycystic kidney disease and Alport syndrome. Acquired conditions (e.g. glomerulonephritis, nephrotic syndrome) are more common over the age of six. The multi-systemic effects of CKD must be taken into consideration for anaesthesia. These include chronic anaemia secondary to reduced erythropoietin production, reduced red cell survival and iron and folate deficiency, with haemoglobin (Hb) concentrations in the region of 60–70 g l^{-1}. Coagulation may be deranged due to platelet dysfunction, bone marrow depression causing thrombocytopenia or heparin from dialysis. Electrolyte abnormalities are common and include hyperkalaemia, hypocalcaemia, hyperphosphataemia and hyper-/hyponatraemia depending on the aetiology. Full blood count, electrolytes and coagulation should be checked preoperatively, and knowledge regarding urine output, fluid balance, fluid restriction, baseline blood pressure and dry weight is vital for any child with CKD undergoing anaesthesia. Oliguric children are at risk of cardiac failure and pulmonary oedema due to fluid overload, whilst polyuric children are at risk of hypovolaemia. Hypertension is common but not universal and may result in left-ventricular hypertrophy. Other cardiovascular consequences include arrhythmia and cardiomyopathy. Respiratory reserve may be reduced by the presence of pleural effusion or diaphragmatic splinting from ascites. Echocardiogram, electrocardiogram and chest X-ray should be considered before anaesthesia. Additional complications with implications for anaesthesia are peripheral neuropathy, encephalopathy, seizures, delayed gastric emptying, reduced immunity, polypharmacy and altered pharmacodynamics and pharmacokinetics (see Chapter 2).

Renal transplantation is the treatment of choice for children with end-stage renal failure. Preemptive transplantation improves growth, quality of life and survival when compared with dialysis. Approximate graft survival at five years is 90% for a live donor compared to 80% for a deceased donor renal transplant. The principles of anaesthetic management include preoperative optimisation, stable intraoperative haemodynamics, optimal perfusion of the transplanted organ and good postoperative analgesia. If required, haemodialysis usually occurs the day before surgery and should be avoided for four to six hours preoperatively to minimise residual heparinisation. Two units of blood should be cross-matched. The anaesthetist should be familiar with local protocols, including antibiotic prophylaxis, fluid management and administration of aspirin and immunosuppression. Children who are dialysed frequently have labile blood pressure, particularly at induction of anaesthesia; fluid boluses and vasoconstrictors may be required. Large-bore peripheral access is necessary for intra- and postoperative fluid replacement. Isotonic crystalloid, such as compound sodium lactate or Plasma-Lyte 148, are suitable for intraoperative fluid requirements. Arterial blood pressure monitoring is necessary in younger children (<20 kg) where the transplant is anastomosed to the IVC and aorta or in older children with relevant comorbidity (where the organ in anastomosed to iliac vessels). The femoral artery should be avoided in children undergoing iliac vessel transplant due to risk of graft vessel thrombosis, but also in younger children who will inevitably require further iliac transplantation in later life. Peripheral or arterial access and non-invasive blood pressure cuffs should not be placed in limbs with arteriovenous fistulae. Central venous pressure (CVP) monitoring is essential via a size-appropriate triple-lumen central venous catheter or a permacath if already in situ. CVP is kept >10 cmH_2O to optimise renal perfusion. Dopamine can be attached to the CVC and primed for children undergoing anastomosis to the IVC and aorta for use at the time of vascular unclamping. Intraoperatively, the patient should be volume loaded, and transfused with packed red cells with a transfusion threshold of Hb <70 g l^{-1}. IVC and aortic anastomoses may require heparin prior to aortic cross-clamping. These cases require large volumes of fluid: up to 200 mls kg^{-1} is not unusual. Communication between the surgeon and anaesthetist is vital for timing of drugs as well as at the point of vascular clamping and reperfusion. Most renal transplant protocols will ask for 1–2 mg kg^{-1} furosemide +/– mannitol to be administered prior to unclamping, and at this point the dopamine may be started at 3–15 mcg kg^{-1} min^{-1}, titrated to effect. Hypotension is common as the new kidney fills with blood. Vasoconstrictor boluses such as 0.5–1 mcg kg^{-1} phenylephrine are often required as the systemic vascular resistance

drops. Meticulous control of blood pressure is crucial to minimise the risk of graft failure due to thrombosis. Target blood pressure is dependent on donor pathophysiology and anatomy. Close communication with the surgeon as to how the kidney appears and feels at reperfusion is essential. There is a risk of arrhythmia secondary to hyperkalaemia when the kidney preservation fluid enters the circulation at unclamping. At our institution, intravenous salbutamol, bicarbonate and calcium chloride are the preferred treatment for hyperkalaemia. The problems of re-perfusion are exacerbated in small children receiving a large kidney. A TAP block provides good intraoperative analgesia for iliac anastomoses. Postoperative analgesia with a TAP catheter inserted under direct vision by the surgeon minimises opiate requirements. A morphine NCA/PCA is otherwise indicated, and it is the aim to extubate this group of children. Some institutions may use epidurals. For children <20 kg undergoing IVC and aorta transplantation, opioid analgesia is typically used intraoperatively. This group of patients remains ventilated postoperatively, usually for one night in order to stabilise haemodynamics after large fluid shifts, and because transplantation of an adult kidney into a small child can impact on ventilation and wound closure. A transplant ultrasound is performed in theatre or the recovery unit. Postoperative fluid balance is managed by the renal team and involves maintenance fluids and replacement of hourly urinary losses.

Key Points

- Paediatric urological surgery is amenable to a variety of regional anaesthesia techniques.
- Antibiotic prophylaxis is required for cystoscopy, major urological and reconstructive procedures.
- Major surgery requires close teamwork with the urologist to identify the complexity of the surgery, positioning needs and appropriate vascular access.
- Wilms nephrectomy can result in major haemorrhage, especially without neoadjuvant chemotherapy or if heminephrectomy is performed.
- Renal transplantation is a major vascular procedure in young children. It involves close teamwork with the surgeons, nephrologists and transplant team.

Further Reading

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