50. Laparoscopic Resection of Renal Masses

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Background

Laparoscopy in pediatric urology has been utilized since the 1970s and has evolved at a rapid pace [1]. Historically, Ehlrich, Kyle, and colleagues initially described laparoscopic nephrectomies for infants and children in the early 1990s, specifically in the setting of multicystic dysplastic kidneys (MCDK) [2, 3]. Advances in technology have made this technique more feasible in the pediatric population and a critical component of surgeon education. The surgeon should have a clear understanding of the indications, renal physiology, tools, and techniques before utilizing laparoscopic surgery.

Laparoscopic resection is an attractive alternative to open surgery given the possibility of superior visualization, the ability to perform fine dissection in limited spaces (such as the retroperitoneum), improved cosmesis, limited analgesic use, and reduced postoperative morbidity [4, 5]. Additionally, as surgical experience and training advance, the disadvantages generally attributed to pediatric laparoscopy, including technical difficulty and longer operative time, are gradually being overcome.

Indications

Renal malignancy accounts for 6–7 % of all childhood tumors [6]. Surgeons are encouraged to manage and treat these conditions using a multidisciplinary approach. It is essential to develop an understanding of the pathophysiology and associated conditions of pediatric renal tumors.

Wilms' tumor (also called nephroblastoma) is the most common pediatric renal malignancy, and surgery is a mainstay of its management.

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Table 50.1. Renal lesions of childhood.

Benign	Malignant
Angiomyolipoma	Wilms' tumor (unilateral or bilateral)
Renal pseudotumor	Clear cell tumor
Metanephric adenoma	Renal cell carcinoma
Multicystic nephroma	Mesoblastic nephroma
Reninoma	Rhabdoid tumor
Ossifying renal tumor of infancy	Multilocular cystic nephroma

Surgical principles established by The National Wilms' Tumor Study Group include understanding key aspects of childhood cancer, surgical expertise in removal without rupture of the tumor, and the ability to intraoperatively stage the patient through assessment of the peritoneum and thorough lymph node sampling [7].

Minimally invasive surgery has been used in Wilms' tumor with success [8]. However, the principles noted above must not be compromised, including removal of the specimen intact and without rupture, which necessitates a larger incision for extraction. As such, MIS should only be considered in appropriately selected patients with small tumors and by those with expertise in laparoscopy to ensure complete excision, intact removal, and lymph node sampling equivalent to that with open surgery.

Refer to Table 50.1 for a list of renal lesions encountered in childhood.

Anesthetic Considerations

Laparoscopy is generally well tolerated by children; however, several anatomic and physiologic differences exist in comparison to adults (see Chap. 1).

Neonates and infants exhibit reduced ventricular compliance, possess a short trachea, and incur increased intra-abdominal pressure resulting in a decrease in functional residual capacity. Hypoxia or visceral stimulation can potentially elicit bradycardia as well [9].

Laparoscopic renal surgery in children can be performed by both retroperitoneal and transperitoneal approaches. The retroperitoneal approach may lead to increased CO_2 absorption and elevated pulmonary artery pressure. These effects are primarily seen in children with central nervous system and/or cardiorespiratory dysfunction [9, 10].

Laparoscopic Radical Nephrectomy

Transperitoneal Approach

Patient Positioning

One must take into consideration patient body habitus, size/location of the renal lesion, and exposure needs when deciding on patient positioning (Fig. 50.1). Positioning can vary from supine to partial flank to full flank. Most cases can be completed in the supine position with a bump placed under the side of the lesion.

In order to increase operative space, the bed may be flexed and/or kidney rest elevated to help widen the angle between the lower ribs and pelvic brim. This may be less beneficial in the younger population due to limited body habitus.

Proper padding of boney sites and soft tissues to ensure patient safety is imperative. The patient is strapped with sturdy cloth tape to allow stability and safety with bed movement.

Port Placement

We find the most predictable point of entry into the peritoneal cavity to be through the umbilical region using an open or Veress needle technique (Fig. 50.2). Either a 5-mm or 10-mm laparoscopic trocar is placed with a 0° scope within the port to allow for direct visualization during entry when using the Veress needle.

Insufflation is started at a pressure of 12 mmHg or less dependent on the age and weight of the patient, with incremental flow of 1–3 L/min. If necessary, higher pressure (up to 15 mmHg) can be used for port placement, after which the pressure should be decreased to the lowest pressure that maintains good visualization.

Two accessory ports are then placed under direct observation after anesthetizing the skin. One working port is placed along the ipsilateral rectus border. The third port can be placed in the midline below the xiphoid. When necessary, an additional port to allow for liver or splenic retraction can be placed subxiphoid as well. Alternatively the original subxiphoid port can be used for retraction and an additional port placed inferiorly based on the anatomy.

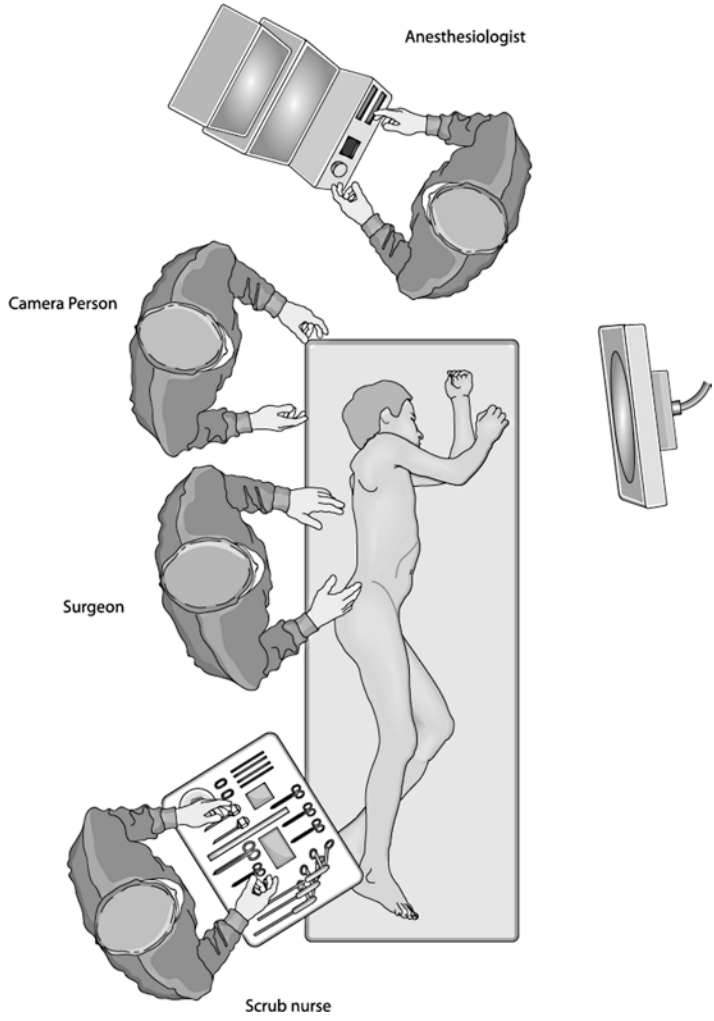

Fig. 50.1. Patient positioning for Laparoscopic Nephrectomy. From Valla JS. Basic Technique: Retroperitoneoscopic Approach in the Lateral Position. In: Endoscopic Surgery in Infants and Children. Bax KMA, et al., eds. 2008:633–638. Reprinted with permission from Springer.

Colon Mobilization

We begin with mobilization of the colon overlying the kidney while maintaining the lateral renal attachments.

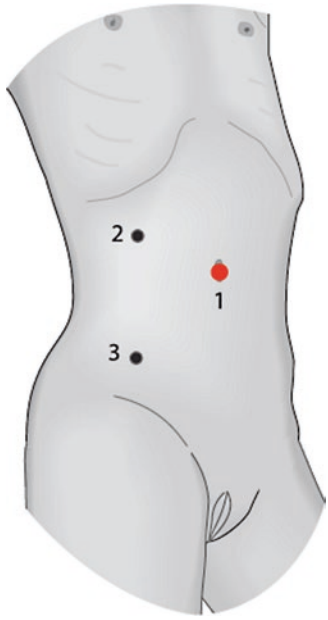

Fig. 50.2. Trocar placement for LN. From Shenoy MU. Total Nephrectomy: Transperitoneal Approach. In: Endoscopic Surgery in Infants and Children. Bax KMA, et al., eds. 2008:639–642. Reprinted with permission from Springer.

The colon is dissected along the white line of Toldt from the splenic flexure on the left or hepatic flexure on the right. Dissection can be performed using harmonic scalpel, cold scissors, or cautery.

Once the ureter is identified as it courses over the psoas muscle, it is followed cephalad to the renal hilum and can be used for retraction. All effort is made to keep Gerota's fascia intact when removing a possible malignant lesion.

Renal Hilum

The ureter and gonadal vein are secured and divided. The hilum should be carefully dissected using gentle technique. Dissection can be performed using a variety of devices. The author's preference is to initially use harmonic scalpel for gross dissection, followed by hook electrocautery for fine dissection using a suction/irrigator with hook attachment. The latter device allows for precise dissection and suction without repeatedly changing instruments.

Efforts should be made to isolate the artery first and vein second. Once isolated, the vessels can be ligated separately with clips. If a 12-mm port is in place, a laparoscopic stapling device with vascular staple load can be used. When difficulty is encountered separating the artery and vein, the entire hilum can be stapled as one, provided adequate visualization. It is important to remember that one can staple or clip across staples, but one cannot staple across previously placed clips.

Secondary renal hilar vessels should be identified and controlled appropriately, with care taken to observe for and control adrenal branches.

Specimen Removal

In the setting of benign indications, the kidney can be extracted from the umbilical region. A 5-mm lens allows visualization through a working port during extraction. The specimen can be divided into smaller pieces laparoscopically or morcellated within a specimen retrieval bag.

If the specimen is possibly malignant or too large for morcellation, a retrieval bag can be deployed and the specimen removed through a Pfannenstiel incision or extension of a port site(s).

Complications

The smaller working space in pediatric patients yields an increased risk of abdominal organ or vascular injury during laparoscopic surgery. Although rare, injury occurring during placement of the initial trocar is a likely cause [11]. Injuries detected intraoperatively should be addressed and repaired. Laparoscopic experience has been found to be the strongest predictor of complication rate during laparoscopic urologic procedures [12].

Retroperitoneal Approach

This approach is preferred by many surgeons due to its convenient access to the renal hilum. The limited retroperitoneal fat in many children can further enhance this advantage. Due to unfamiliar anatomy, fewer landmarks, and limited space, this approach can be technically challenging and is best reserved for experienced laparoscopic surgeons or those who have specific training in its use. Retroperitoneal

techniques can be performed in either the lateral or prone position. Both approaches have been reported to have similar outcomes and complication rates [13].

Lateral Approach

We place the patient in the flank position and flex the bed to aid in widening the operative field (Fig. 50.3). The patient is safely secured and pressure points are appropriately padded.

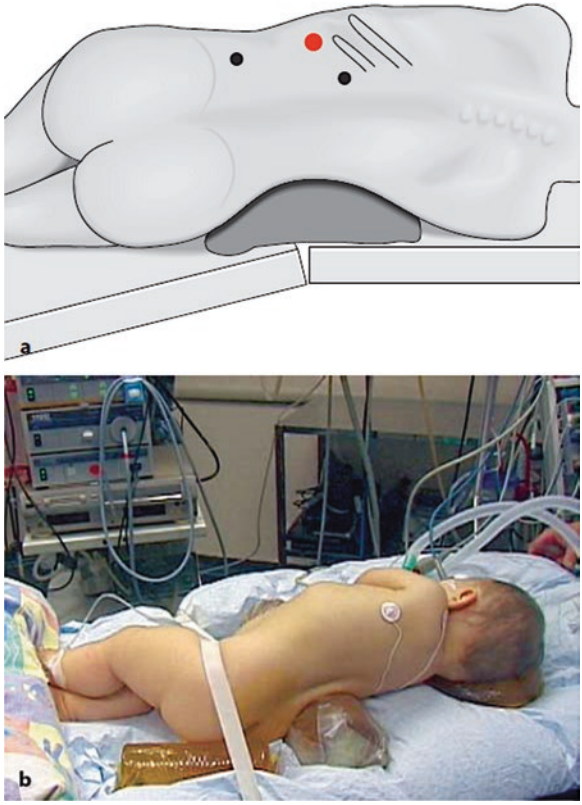

Fig. 50.3. Positioning for lateral retroperitoneal approach. (**a**) Older child, (**b**) baby. From Valla JS. Total Nephrectomy: Lateral Retroperitoneoscopic Approach. In: Endoscopic Surgery in Infants and Children. Bax KMA, et al., eds. 2008:643–649. Reprinted with permission from Springer.

Access is obtained with an incision approximately 1 cm off the tip of the 12th rib. The muscles layers are dissected and peritoneum avoided. The retroperitoneal space can be developed with commercial balloons or using a red rubber catheter and the finger of a glove [14].

Once access to the retroperitoneal space is obtained, a blunt 5-mm or 10-mm trocar is placed to further develop the retroperitoneal space using careful dissection and insufflation. Insufflation should be set to less than 12 mmHg. Two 5-mm trocars are placed under direct visualization anterior to the paraspinous muscles and superior to the anterior superior iliac spine in the anterior axillary line. It is important to avoid transperitoneal port placement. Should peritoneal insufflation occur, a fine angiocatheter can be placed through the abdominal wall as a "vent" to prevent the insufflated abdomen from compressing the retroperitoneum.

The psoas muscle may be used as an anatomic landmark to approach the kidney posteriorly. Once the renal hilum is identified, the artery can be ligated followed by the vein.

The specimen can be extracted via the 10-mm port site as discussed previously.

Prone Approach

The patient must be positioned between chest and hip pads to prevent abdominal compression on the operative table. The initial incision is made at the costovertebral angle, lateral to the paraspinous muscles. Blunt dissection is carried down just lateral to the quadratus lumborum to enter the retroperitoneum. A 10-mm port is placed and pneumoperitoneum further develops the retroperitoneal cavity. Two additional 5-mm ports are placed, one in the posterior midaxillary line approximately 2 cm above the iliac crest and the other at the tip of the 12th rib (Fig. 50.4). The psoas muscle is anteriorly placed in the prone position and therefore is difficult to use as anatomic landmark in the prone position. Similar to the flank technique, dissection and specimen extraction are performed as stated above.

Hand-Assisted Approach

Hand-assisted laparoscopy allows increased tactile sensation, improved depth perception and simple specimen removal and may increase the ease of the operation, particularly for those with less laparoscopic experience.

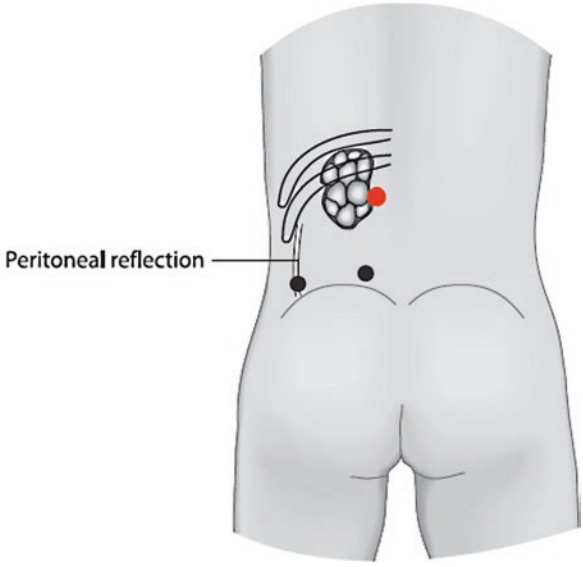

Fig. 50.4. Trocar placement for prone retroperitoneal approach. From Peters CA. Total Nephrectomy: Prone Retroperitoneoscopic Approach. In: Endoscopic Surgery in Infants and Children. Bax KMA, et al., eds. 2008:651–657. Reprinted with permission from Springer.

An incision must be made to accommodate the surgeon's hand. Hand-assisted laparoscopy can be beneficial in cases in which pure laparoscopic resection may prove to be difficult (i.e., prior surgery, infection, etc.). Furthermore, pure laparoscopic surgery may be converted to hand-assisted by extending a trocar site, which can be useful to obtain vascular control or repair an injury in an emergent setting. This technique can be employed for the same indications as transperitoneal or retroperitoneal nephrectomy. Hand assistance is particularly helpful during pediatric living donor nephrectomy where a large incision is required for extraction.

Patient Positioning and Trocar Placement

- Patients are positioned in a similar fashion as for pure laparoscopic nephrectomy.

- The initial incision is for the hand port and will obtain access into the peritoneal cavity
- Pneumoperitoneum is initiated, and subsequent trocar placement is performed under direct visualization using the 30° lens through the hand port.
- Air leak may occur; therefore a variety of devices have been developed to stabilize pneumoperitoneum by providing a seal against the abdominal wall.
- Surgery proceeds as previously described, with the specimen easily removed intact via the hand port.

Laparoscopic Partial Nephrectomy

Background

In the pediatric population, laparoscopic partial nephrectomy (LPN) or heminephrectomy is most commonly utilized to remove a nonfunctioning upper or lower pole resulting from duplication anomalies. Laparoscopic partial nephrectomy in the setting of malignancy is less common; however in select patients, it is an effective approach [14].

When compared to open partial nephrectomy, the laparoscopic technique has been shown to provide a shorter hospital stay, reduced pain medication requirements, and improved cosmesis. However, operating time and costs may be increased [15, 16].

Transperitoneal LPN for Possible Malignant Lesions

This approach allows for a larger working space, and the initial portion is performed similarly to radical nephrectomy, although additional ports may be needed to assist with vascular control or visualization.

Once the colon is mobilized and ureter identified, the hilar vessels are isolated.

At this point intraoperative ultrasonography may be used to confirm the characteristics of the renal mass (location, depth, etc.).

Gerota's fascia is entered and the renal capsule surrounding the tumor is scored with cautery.

Unless the lesion is very exophytic, the renal hilum is then clamped using laparoscopic bulldog clamps. Cold shears are then used to excise

the tumor completely. All efforts should be made to minimize warm ischemia time, historically with a goal of less than 30 min.

Hemostasis is critical at this point in the procedure. Options include direct suturing of vessels, hemostatic agents, and bolstering devices. The author's preference is for laparoscopic suturing over a bolster with the addition of hemostatic agent.

In certain situations, the tumor size and location may require entry into the collecting system in order to obtain negative surgical margins. Many surgeons suture the collecting system closed with absorbable suture, although low leak rates have also been seen without formal closure [17]. Many surgeons find that robotic assistance provides a large advantage for intracorporeal suturing. A ureteral stent may be placed based on surgeon preference. A drain should be left near the kidney postoperatively in case of urine leak.

Retroperitoneal LPN

The retroperitoneal approach is technically challenging, but may be an advantage for posteriorly located upper pole tumors. Furthermore, vascular anatomy, prior transperitoneal surgery, and obesity may be additional factors which prompt one to consider a retroperitoneal approach. Most often this approach is used for nonfunctioning renal segments.

The approach for a potentially malignant lesion is similar to the above.

For nonfunctioning segments, the dysplastic kidney can usually be visually identified and excised with cautery, harmonic scalpel, or other devices. Care should be taken to avoid resecting functioning kidney. The base of the resection is often cauterized, and hemostatic agents may be applied if there is concern about the risk of bleeding.

Complications

During any minimally invasive kidney operation, it is essential to identify and be able to manage intraoperative complications. One should never hesitate to add additional ports to aid with suction, hemostasis, or visualization. Further, one should always be prepared to convert to an open procedure if necessary. The following complications can occur:

- Pressure- and nerve-related complications with improper patient positioning.
- Vascular, bowel, or adjacent organ injury.
- Gas embolism.
- Major vascular injury, particularly at the hilum or, retroperitoneal hematoma.
- Ureteral or renal pelvis avulsion may yield ureteral strictures or urinoma.

Summary

- Laparoscopy is a critical component of surgeon education and a key component of the management of pediatric renal masses.
- Maintaining an awareness of the evolving technology and techniques available is fundamental to optimizing patient care.
- The surgeon should have an understanding of the transperitoneal, retroperitoneal, or hand-assisted laparoscopic approaches and consider their role in various clinical scenarios.
- The ability to identify and manage perioperative complications is essential.
- Furthering ones understanding of these conditions and practices will remain a critical part of caring for pediatric patients moving forward.

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