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FROM THE GUEST EDITOR

As in adult urologic surgery, laparoscopic procedures have advanced to a high degree of proficiency in pediatric urologic surgery, both in ablative and reconstructive surgery. Laparoscopic pediatric urologic surgery is here to stay, and the pediatric urologists are now faced with the need to hone their surgical skills, due to the interest and even demand for such procedures.

As Guest Editor, I invited several specialists from different parts of the world to present their experience in distinct and innovative laparoscopic techniques in the field of pediatric urology, hoping that it would stimulate the interest of those who are beginning their professional activity, as well as enrich the experience of those who are already well trained in these procedures. Although this issue does not include all the possible surgeries and techniques in the field, those presented are frequent procedures in our daily practice, and their authors have undisputed expertise in their topics. I sincerely hope that all readers can enjoy reading this issue and learn something from it.

FROM THE EDITOR

Anthony A. Caldamone, M.D.

At a meeting of the Society for Pediatric Urology in the early 1990’s, Rick Ehrlich made a presentation on the use of laparoscopy for the diagnostic and therapeutic management of the nonpalpable testis. This was one of the first presentations that I had heard on the application of noninvasive technology in pediatric urology. In fact, history will show that the pediatric urology led the way in the application of laparoscopic technology. When I finally adopted Rick’s recommendations, both adult urologists and general surgeons at my institution were anxious to come to the OR and watch this new technology and practice.

What Francis Dénes and his contributors have demonstrated for us in this issue of DPU is how far this technology has advanced within our own subspecialty. The contributors to this issue have been on the forefront of this technology, continuing to push the envelope, but as you will appreciate, continuing to evaluate the results objectively as new techniques become adapted. What we have learned in pediatric urology is that the risk-benefit ratio for this technology in children is not always as obviously favorable as in the adult population. Therefore, a more critical appraisal of these new technologies is necessary to provide data. Comparative studies will be the ultimate endorsement. Each of these contributors imply that the limitation in the application of the technologies is not the size of the patient nor the instrumentation, but the commitment to overcome the steep learning curve which requires both focus and time.

Rick Erhrlich concluded his landmark presentation with a very simple slide, white on black the slide stated: “You are either the steamroller or the road.” You have the choice.
Partial nephrectomy is usually done in children to remove a non-functioning upper or lower pole secondary to complicated duplex anomalies of the kidney. The usual pathology of the upper pole is obstruction associated with a ureterocele or incontinence secondary to an ectopic ureter. The usual pathology in the lower pole is reflux and less frequently obstruction at the UPJ with loss of function. Laparoscopic partial nephrectomy is technically more demanding than total nephrectomy. These procedures can be performed using a retroperitoneal or transperitoneal approach. Laparoscopic techniques are well suited to this procedure, with the benefits of perfect global exposure to the anatomy of the full kidney and its vascularity without the need to mobilize the remaining part of the kidney. Another advantage is that there is no need for a second inguinal incision to excise the distal ureter. Our preference is the retroperitoneal approach, as it provides a posterior access to the kidney without dissecting the main renal pedicle, an unavoidable step during the transperitoneal anterior approach. Retroperitoneal access can be achieved either posteriorly in a prone position or in a lateral decubitus position. Borzi compared the two approaches and found that the lateral approach creates more inferomedial space, gives better access to ectopic kidneys, and allows for a complete ureterectomy in all cases.\(^1\)

### Specific Important Technical Points of Retroperitoneal Partial Nephrectomy

We routinely use the lateral retroperitoneal approach as previously described (Fig. 1 and 2).\(^2\) The upper pole ureter is identified at the lower pole of the kidney, and dissected very close to its wall to avoid injury to the vascular supply of the lower pole ureter. We find it helpful to ligate the proximal ureter before cutting it, so the proximal ureter remains dilated facilitating the dissection of the upper pole. Because the exposure is posterior, contrary to the transperitoneal anterior approach, the upper pole ureter is lifted off the vessels by blunt dissection superiorly. The upper pole ureter is used as a handle to facilitate this part of dissection. The plane between the dilated upper pole pelvis and the lower pole parenchyma is easily identifiable by blunt dissection until the edges of the thin parenchyma of the upper moiety are recognized. At this step, the upper pole vessels are identified running from the aorta or the renal vessels to the upper pole parenchyma. They are either clipped or coagulated depending on their size. The upper pole is identified by color changes after vessel ligation and by the difference in appearance between the normal lower pole and the dilated dysplastic upper pole. The duplex system anomalies have a well-defined vascular line of demarcation between the upper and lower poles of the kidney. However, sometimes it is difficult to individualize upper pole vessels, and the parenchymal transection is started before vascular control of the upper pole. Transection can be done by electrocautery, but we prefer the Harmonic scalpel with the curved jaws, as it provides a clean cut at the junction between the upper and lower poles.

To minimize mobilization of the lower pole and consequently the risk of indirect vascular trauma of the renal pedicle, the lower pole remains attached to the peritoneum during all the steps of the procedure. The upper pole is completely freed from peritoneal attachment before transecting the parenchyma to avoid transperitoneal bowel injury.

### Upper Pole Partial Nephrectomy

If upper pole partial nephrectomy (UPN) is done using a transperitoneal approach, the proximal ureter must be passed behind the renal hilum and delivered under the vessels from above after mобi-
The technique should be standardized to reduce complications. This step is technically the most difficult part of the procedure and requires dissection of the lower pole vessels. Identification of the upper pole vessels and parenchymal transection are identical to the retroperitoneal approach.

**Lower Pole Partial Nephrectomy**

For retroperitoneal lower pole partial nephrectomy (LPN), access is the same as for the upper pole. The lower pole ureter is identified and followed to the lower pole pelvis to be sure of its identity. Contrary to the upper pole nephrectomy, full dissection of the lower pole vessels is necessary before transecting the parenchyma. As the main pathology is reflux with repeated infections, the lower pole is usually retracted and easily distinguished from the healthy upper pole parenchyma. The ureter should be ligated close to the bladder to avoid postoperative reflux into a long ureteral stump. The line of transection is sometimes difficult in lower pole nephrectomy if associated with dilated calyces. We often find that the calyces are deeply involved in the parenchyma of the upper pole. Currently we do insert a ureteral catheter in the upper pole ureter and connect it to a methylene blue syringe to inject at the moment of the transection. This is also done in upper pole nephrectomy procedures if there is any doubt about the diagnosis or the absence of major dilation of the upper pole ureter. If there is a leak of blue, the tear can be easily identified and sutured, and the catheter in this case would be kept for 48 hours. This has happened in my experience in 2 cases and both were in upper pole nephrectomy.

**Results and Complications**

Operative time is a major concern in developing a new technique in a busy institution. We have shown that there is no difference in the operative time between open surgery and retroperitoneal laparoscopic partial nephrectomy. The hospital stay was significantly shorter in the laparoscopic group compared with the open surgery group. Robinson et al., in a prospective non-randomized study, compared costs and outcomes of laparoscopic partial nephrectomy with open surgery in children. The mean operative time in the laparoscopic and open groups was 200.4 and 113.5 min, and the mean hospital stay was 25.5 and 32.6 h, respectively. Partial nephrectomy in children remains a challenging procedure even in experienced hands. Valla et al have reported 37% of intraoperative complications, mainly residual perirenal collections at the transection line. The major complication is, however, the loss of function of the remaining moiety. We have lost one kidney early in our experience in a 7-year-old child after upper pole nephrectomy. We believe that the main surgical mistake was to free the remaining moiety from the peritoneum increasing the risk of twisting the main renal pedicle. Wallis et al have reported functional loss of the remaining moiety in 2 children aged 6 and 7 months. They insist on the importance of following these children by DMSA renal scan and not only Doppler studies, which may show normal hilar blood flow. They concluded that in children under one year there is a higher risk for complications. We believe that the main surgical mistake was to free the remaining moiety from the peritoneum increasing the risk of twisting the main renal pedicle. Wallis et al have reported functional loss of the remaining moiety in 2 children aged 6 and 7 months. They insist on the importance of following these children by DMSA renal scan and not only Doppler studies, which may show normal hilar blood flow. They concluded that in children under one year there is a higher risk for complications.

**Conclusions**

Partial nephro-ureterectomy remains a challenging laparoscopic procedure. The main limiting factor is the learning curve and not the age at surgery or the degree of dilatation. Nevertheless, in children under one year of age, surgery should be done with great care and by the most experienced surgeon of the team. We believe that both retroperitoneal and transperitoneal approaches are now safely feasible with comparable results, and recommend that the surgical teams concentrate on and improve the technique of their choice, instead of trying to compare approaches. It is clear from the published reports that the main objective is to avoid the high complication rate in the beginning of the experience. Mentored learning of the procedure is recommended before starting to proceed on one’s own. We learned from our early complications that some aspects are necessary to make the retroperitoneal approach easier and safer:

- The technique should be standardized to reduce complications,
- The remaining moiety should be kept attached to peritoneum,
- The pathological ureter should be kept dilated by ligature at the beginning of surgery,
- Retrograde insertion of ureteral catheter to allow methylene blue injection is necessary in cases of lower pole nephrectomy or atypical upper pole nephrectomy.

**References**

Adrenalectomy

In 1992 the laparoscopic approach to the adrenal gland was first reported. Since then, several studies have been published, establishing the efficiency and safety of laparoscopic adrenalectomy in adults. International experience with the laparoscopic technique for adrenal disease in children and adolescents is limited. It began with the pioneer Japanese experience, through a program of detection of neuroblastoma in the newborn.

Some authors presented their experience with laparoscopic adrenalectomy in children and adolescents that had different medical indications for surgery. They reported cases with primary carcinoma, cyst, teratoma, ganglioneuroma, pheochromocytoma, cortical hyperplasia, medullary hyperplasia, nonfunctioning adenoma, virilizing adenoma, leiomyosarcoma, adrenogenital syndrome, and Cushing’s syndrome (cortical adenoma and pituitary disease). Few reports of bilateral surgery were registered, mostly in patients with pheochromocytoma due to the von Hippel-Lindau syndrome. Some of these patients underwent partial adrenalectomy. A review of the literature published in 2004 included 83 patients from several medical services, with solid tumors between 10 and 80mm (average of 40mm), most of which were operated transperitoneally. There was a 10% conversion rate and only one case was transfused. The average surgical time was 120 minutes and there were few complications.

Most authors have a preference for the lateral transperitoneal approach, which we will briefly describe. The patient is in the 45-degree lateral decubitus position. Pneumoperitoneum is established with a Veress needle. We usually use a 10mm. 0-degree optical laparoscope inserted just below the umbilicus. The other 2 or 3 ports (5/11mm) are inserted under direct vision. On the right side, after the liver is lifted, the posterior peritoneum is incised transversely just below the liver to expose the inferior vena cava and adrenal gland. There is no need to mobilize the colon on the right side. Dissection begins on the medial border of the adrenal gland between it and the inferior vena cava, to identify and ligate the main adrenal vein, which is short and enters the vena cava lateral. The adrenal vein is sectioned between clips. Dissection progresses from the medial to the lateral border and from the superior to the inferior border of the adrenal gland. Small vessels are cauterized and sectioned. During the operation we avoid touching the gland directly with graspers and scissors to preserve its integrity and avoid hemodynamic instability, which occurs in patients with pheochromocytoma. After dissection is complete the adrenal gland is entrapped in a plastic bag and removed intact from the abdomen through a port incision. The surgical field is inspected and the ports are closed. Drains are not placed. On the left side the colon is always mobilized. To mobilize the left colon the peritoneum is incised on the line of Toldt from the splenic angle to the pelvic rim. The attachments of the colon to the spleen is incised to mobilize medially the spleen and pancreas tail. After medial mobilization of the left colon, spleen and pancreas tail, the anterior renal fascia is completely exposed and incised just over its medial attachment. The trunk of the left renal vein is identified. The adrenal vein is identified at the superior margin of the renal vein. Dissection begins close to the left renal vein to isolate and ligate the main adrenal vein between clips, which is sometimes difficult in larger tumors. Dissection progresses from the medial to the lateral border and from the superior to the inferior border of the adrenal gland. The procedure is the same for the right adrenal gland. After the adrenal gland is removed the colon is left in its anatomical position without sutures.

We published our pioneer Western experience in 2002, with 13 patients, mean age 6.3 years, a 15.4% conversion rate and good late results, without postoperative complications. Average operative time in unilateral nonconverted procedures was 107 minutes (range 25 to 195). Blood transfusion was required in 1 case (7.7%). Average hospital stay was 5.5 days (range 1 to 17). Average postoperative followup was 16 months (range 1 to 60). The final clinicopathological diagnosis was virilization in 4 cases, Cushing’s syndrome in 2, pheochromocytoma in 2, neuroblastoma in 2, Cushing’s pituitary disease in 1, teratoma in 1 (the first reported in the literature) and primary carcinoma in 1.

Our personal experience and analysis of the published reports, which are few, allow us to reach the following conclusions:

1. Total or partial laparoscopic adrenalectomy in children and adolescents is technically feasible, regardless of the patient’s age and weight. The limit of the tumor volume that can be operated through laparoscopic technique depends on each surgeon’s experience;
2. Most authors show a preference for the lateral transperitoneal approach, with a conversion rate between 10 and 20%;
3. This type of surgery is predominantly indicated in benign diseases, unilateral or bilateral, and in selected cases of malignant diseases, especially neuroblastoma;
4. The results that have been obtained thus far are as good as those reported in adults, suggesting that the laparoscopic adrenalectomy should be considered the gold standard of adrenal surgery in children and adolescents.

References

Laparoscopy in Disorders of Sex Development

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The correct clinical evaluation of patients with disorders of sex development (DSD) allows the identification of the primary disease and reduces the probability of inappropriate management regarding sex assignment. The aim is to offer the best quality of life, reconciling structural limitations with the functional potential of both internal and external genitals, aligning them as best as possible to the assigned gender of the patient. Due to its minimal invasive nature, absence of scars, efficacy and low morbidity, laparoscopy emerged as an optimal modality for evaluation and treatment of patients with DSD. Diagnostic laparoscopy is restricted to 46,XX DSD to differentiate 46,XX testicular DSD and ovotesticular DSD in male patients with genital ambiguity and impalpable gonads. Therapeutic laparoscopy is more ample, being employed to remove the ductal structures and gonads that are either incompatible with the social gender, or gonads that are non-functional and dysgenetic, as well as those that are malignant or present potential of malignant degeneration (patients carrier of Y-chromosome with dysgenetic gonads). Associated conditions such as hernia, cryptorchidism and urinary malformations can also be managed with laparoscopy. The disorders of sex development conditions for which laparoscopy is employed are the following:

46,XX DSD: In the exceptionally virilized 46,XX patient with male gender identity, laparoscopy is indicated for the removal of the female gonads and müllerian derivatives.

46,XY DSD: Whenever possible, 46,XY patients with an underdeveloped phallus and female gender identity should undergo feminizing genitoplasty and laparoscopic removal of intra-abdominal dysgenetic gonad or normal testis. The uterus, even when rudimentary, should be retained, since estrogen replacement at pubertal age may initiate menstruation. When the gender identity of the patient is male, orohaphalloplasty and neourethroplasty should be performed, and the normal testes must be secured to the scrotum by laparoscopy, with removal of the uterus and the vaginal component of the urogenital sinus. If the gonads are dysgenetic, they should be removed along with the müllerian structures.

46,XX Ovotesticular DSD: These patients present coexistent ovarian and testicular tissue with variable configuration and asymmetric ambiguous external genitalia. Generally, treatment is oriented towards the female gender role, with laparoscopic removal of the testis or the testicular portions of the ovotestis, associated with feminization of the external genitalia. Patients with an enlarged phallus and/or male identification can be treated with laparoscopic removal of the female gonads and ductal structures, orchopexy of the remnant testes, and associated masculinization of the external genitalia.

Gonadal dysgenesis: Patients with 45,X karyotype or mosaicism with 45,X lineage associated with other cell lines with the presence of Y-chromosome may have rudimentary or streak gonads that must be removed due to malignant potential.

OPERATIVE TECHNIQUE:

No specific preoperative preparation is needed, except enema in obstipated patients. The patient is positioned in a prone Trendelenburg position, the arms alongside the body. The monitor should be at the foot of the patient. When concomitant genitoplasty is planned, the genital area must also be prepared and exposed. The genitalia and inguinal regions should be reevaluated with the patient under anesthesia. Bladder catheterization is done on the operative field. Usually a three trocar approach (1 umbilical and 2 iliac) is employed, with an eventual fourth suprapubic access to mobilize the bladder if necessary.

Gonadectomy is a straightforward procedure, since the gonads are easily identified and have an easily accessible pedicle. The possible occurrence of dysgenetic or neoplastic gonads, sometimes with an odd appearance, should not be overlooked (Figure 1). It is necessary to evaluate the internal inguinal orifices, which may be patent. The contents of the inguinal canals should be explored if the internal inguinal ring is patent and gonads are not identified in the abdominal cavity. A standard laparoscopic orchidopexy can be done when a normal testis has to be relocated to the scrotum. In cases of agonadism, neither gonadal structure, nor its vessels are found in the abdominal cavity, but ductal structures may be present. These extend between the gonads and the retrovesical space. In the midline, behind the bladder, it is possible to identify the (hypoplastic) uterus (Figure 2). Removal of ductal structures is easily performed in most cases, but hysterectomy with resection of the vaginal component of the urogenital sinus may be difficult, due to its retrovesical extension. When a short vaginal component joins the urethra above the pelvic floor, complete resection of the vagina can be performed entirely laparoscopically, but care must

Figure 1: Dysgenetic (“Streak”) left gonad being removed in a 17-year-old 46,XY DSD patient.

Figure 2: Hysterectomy in a 3-year-old 46,XX ovotesticular DSD patient.

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Introduction

Videolaparoscopy has been reported for diagnosis and staging of pediatric solid tumors such as neuroblastoma, adrenal carcinoma and ovarian teratoma. Recently, this procedure has been successfully extended to the treatment of Wilms’ tumor, which comprises almost 90% of renal masses in children.

Open surgery is the classic approach for Wilms’ tumor resection, and includes a complete inspection of abdominal cavity, lymph node sampling and radical nephrectomy without neoplastic cell spillage. In general, preoperative chemotherapy decreases tumor size and induces the formation of a pseudocapsule, reducing the risk of tumor rupture, therefore, enabling a safer and easier surgical resection.

Although the SIOP has always recommended preoperative chemotherapy, the NWTS protocols have performed surgical resection of the tumor as the first step of treatment. Nevertheless, the final results of overall and disease free survival of both groups are similar. The Brazilian Cooperative Group for the treatment of Wilms’ tumor is committed to the SIOP 2001 protocol, therefore, all our patients receive preoperative chemotherapy, offering the opportunity to apply laparoscopic radical nephrectomy in selected cases. The procedure is indicated in unilateral non-metastatic Wilms’ tumors that present significant reduction in tumor size after chemotherapy using a four-week

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schedule of vincristine and actinomycin-D (Figure 1). A retrospective analysis of the characteristics of our patients submitted to the procedure shows that the ratio between the tumor’s largest dimension on the post-chemotherapy CT scan and the patient’s height ranged from 0.04 to 0.096, indicating that the tumor’s dimensions of our patients were always less than 10% of the patients’ height. We think this could be an useful index for helping the surgeon to consider the laparoscopic approach in the management of this neoplasia. Tumors that remain significantly large after preoperative chemotherapy or present extensive adhesions to the liver, spleen or diaphragm are best treated by open surgery. We also do not recommend laparoscopic nephrectomy for tumors not exposed to preoperative chemotherapy, even if they are small, due to the risk of intraoperative tumor rupture and neoplastic cell spillage.

Surgical Technique

The patient is in a 30° contralateral supine position, under general anesthesia. Pneumoperitoneum is achieved with an umbilical puncture with the Veress needle, and the abdominal cavity is insufflated to a pressure of 12 mmHg. A 5-10 mm trocar is placed infraumbilically for the camera, a 3 mm one near the xyphoid, another 3-5 mm at the iliac fossa and a 3-5 mm subcostally at the anterior axillary line, both sites according to tumor location (Figure 2).

Laparoscopic evaluation of abdominal cavity is always performed in the search of metastasis. After mobilization of the colon, Gerota’s fascia is identified, as it includes a very well defined fibrous tissue (pseudocapsule) that involves the affected kidney, as result of preoperative chemotherapy (Figure 2). The dissection is then extended to the vessels, beginning with the vena cava on the right side and the renal vein on the left. Both the renal vein and artery are identified, dissected, ligated with polypropylene clips as proximally as possible and sectioned. The spermatic and adrenal veins, as well as the ureter, must also be identified and sectioned on both sides, to ensure easier mobilization of the specimen. The kidney and perirenal fat are then dissected “en bloc”, and in most cases this is easily accomplished, except in cases with adhesions to the liver or diaphragm, when great care must be taken to avoid injury. At this point, the harmonic scalpel is very useful. After complete mobilization of the specimen, it is placed in a plastic retrieval bag introduced through a Pfannenstiel incision. Before removal of the tumor through this incision, pericaval and peri-aortic lymph node samples are also obtained. The incision and ports are closed without drains (Figure 3). In our experience with 14 patients, operative time ranged from 120 to 180 minutes (average 147 minutes), and the tumor was completely resected without rupture in all cases (Table 1). There were no short or long term postoperative complications in our series, except two cases of prolonged ileus. No tumor relapses were observed and the aesthetical result were very good (Figure 4).

References


Table 1 - Results of laparoscopic nephrectomy in children with Wilms’ tumor.

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<th>Height of patient (cm)</th>
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Laparoscopic Extravesical Ureteral Reimplantation (LEVUR)

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The minimally invasive surgery approach for vesicoureteral reflux (VUR) has gained acceptance and several techniques have emerged. The laparoscopic extravesical ureteral reimplantation (LEVUR) has emerged relatively late, compared to other procedures on the urinary tract, as a very effective and safe procedure.

The most important steps are described as follows. The patient is positioned supine and a Foley catheter is inserted. Sterile preparation is done from the xiphoid to the genital area. The surgeon’s position should be at the head of the patient, no matter which ureter is to be treated. Three trocars are used and the right-sided trocar should be a 5mm for the harmonic scalpel (for right handed surgeons). A 30 or 45 degree lens is recommended in order to obtain a better visualization of the postero-inferior side of the bladder.

The initial approach in females should be through the anterior surface of the broad ligament, with care of not cutting through the posterior surface of this ligament. It is necessary to incise the round ligament of the affected side in order to reach the most inferior part of the ureter. By doing this, there is a great increase in working area, making the operation easier and enabling a wider range of movements during the procedure.

The peritoneum is incised on the lateral side of the ureter, with great care to not injure the ovarian vessels that run alongside the ovarian suspensor ligament, which has to be bluntly separated. With this maneuver, a complete access is obtained of the now free middle and distal thirds of the ureter. It is necessary to make sure that the vesicoureteral junction is precisely identified. In order to do so, rami of the inferior vesical artery must be identified and cauterized with the harmonic scalpel. In males, great care is necessary to avoid injury to the vas.

After completing the dissection, the ureter is placed on top of the bladder, in order to evaluate the length of detrusor to be incised. The line of incision is demarcated with the electrocautery, which also achieves hemostasis. The bladder wall is held with a grasper and then a mucosa bulging incision is done in the muscle (similar to a pyloromyotomy) with the harmonic scalpel. Filling the bladder partially facilitates this maneuver. The few muscle fibers that are not divided are cut using blunt tip scissors. Also, a dissector can be used to spread the muscle fibers. Once the detrusor is divided, the mucosa is inspected and leaks are searched and sutured. In case of a small perforation, repair is not necessary, requiring the urinary catheter in place for a longer period.

A polyester 2-0 suture, with RB-2 needle is brought into the abdominal cavity. With the ureter oriented towards the top of the bladder, the needle is passed through the lateral lip of the detrusor incision. The needle is then passed below the ureter and through the medial lip of the incision. The ureter is now pushed into the detrusor trough, and the muscle approximated by the suture above it, creating a tunnel. Intracorporeal knots are used and care is taken not to strangulate the ureter. This can be assessed by intermittently checking that the ureter slides easily in the tunnel in order to avoid ureteral stenosis. Two to three more stitches are placed with great caution, in order to prevent incorporating the ureter. Assessment of a floppy detrusorrhaphy and a non-ectasic ureter is important. The ends of the round ligament are united and the broad ligament is repaired. An immediate post-operative cystogram is performed in the operating room, to confirm the absence of VUR. No urinary catheter is left in place in the cases without mucosal perforation.

In our recently reviewed experience from January 2001 to April 2008, we have operated on 42 renal units in 35 pediatric patients (28 with unilateral VUR, 7 with bilateral VUR). All were II/III grade VUR. Age range is 12 to 62 months (average 48 mos.). Of the unilateral cases, 4 had duplex kidneys. All the ureters were successfully reimplanted without postoperative stenosis. All 7 bilateral cases were repaired in a single procedure. None of these patients presented postoperative bladder emptying difficulty. Operative time averaged 110 minutes in unilateral and 180 minutes in the bilateral cases. All VUR resolved completely, except in one renal unit in which the VUR improved from a grade III to a grade I. There were 4 mucosal perforations that were treated with 72 hours of a bladder catheter. One had a voluntary removal of the catheter immediately after discharge, and developed an urinoma, that was managed with open exploration and repair.

Follow-up has been 0-7 years, and three patients presented urinary tract infection. All 4 cases with duplex kidneys and the 7 bilateral (continued on next page)
cases had a total VUR resolution and have had no urinary infection during follow up. We recommend this technique even in bilateral and duplicated collecting systems.

A recent publication that reviews the treatment of VUR by minimally invasive approach reports the benefits and advantages of LEVUR. This review describes worldwide experiences, including ours. Due to this high success rate, we believe that the LEVUR will become the surgical treatment of choice, place now occupied by the Cohen technique.

References
We initiated our program of laparoscopic pyeloplasty at A.I. duPont Hospital for Children in August, 2004 after having considerable experience with laparoscopic ablative surgery in children. Initially we offered this approach only to children over 3 years of age and gradually expanded the application to all ages and to re-operative pyeloplasty. To date we have done more than 70 pediatric pyeloplasties, which provide the foundation for the recommendations in the present article. The operations have been performed by 4 attending surgeons, often collaborating with one another and have also been used as part of our training program for pediatric urology. The laparoscopic approach has not in any way changed the indications for the operation.

We use the transperitoneal approach since we see no advantages to the more cumbersome retroperitoneoscopic approach. We have not experienced injury to abdominal viscera or postoperative complications due to adhesions and feel that the improved visualization and increased working space is beneficial in this approach.

A cystoscopy, retrograde ureteropyelo-gram and placement of a double J stent are always performed at the beginning of the procedure. We consider the retrograde pyelogram essential to delineate the anatomy and assess the length of the abnormal ureteral segment. We find retrograde placement of the stent more expeditious than antegrade placement. In children under weighing 10 kilograms or less, we use a total body prep to avoid re-prepping and re-positioning.

The initial access to the peritoneum is umbilical using the blunt Baile technique with a 5 mm camera port. Pneumoperitoneum is established at 8 mm of mercury for infants and small children and 12 mm in older children. We normally use 2 additional 3 mm ports; rarely in a right pyeloplasty may a 4th port for a liver retractor be necessary. Additional port placement for the left side is in the epigastrium, left of the ligamentum teres, and in the hypogastrum at the level of the midclavicular line. For the right side, and for a right handed surgeon, we prefer to place the upper port to the right of the midline to better align the needle driver with the suture line.

The right UPJ is always approached by taking down the hepatic flexure of the colon. On the left side we use the transmesocolonic approach whenever possible. We avoid dissecting the ureter excessively and minimize the use of cautery around it. Once the UPJ is exposed, we place 2 percutaneous traction sutures of 4-0 Prolene, 1 at the junction, lateral to the ureter and one in the proximal and medial aspect of the pelvis. These sutures suspend the area of the anastomosis, minimizing the need to manipulate the tissues or suction. The pelvis is cut first; reduction of the pelvis is only done in cases of extreme dilatation.

If a crossing vessel is present, the ureter is now transposed anterior to it. Leaving part of the pelvis attached to the ureter aids in the orientation to suture it. The spatulation should be long enough to reach normal ureter with at least 1 cm margin. The anastomosis is done with 5-0 or 6-0 Monocryl. In the past we have also used Vicryl and PDS. We prefer Monocryl because it does not curl, is easier to manipulate and minimize the use of cautery around it. Once the UPJ is exposed, we use a running suture that starts in the posterior wall away from the apex and runs around the corner. Visualization of the critical apical area is easier if the suture is carried inside the real pelvis and ureter. Usually 2 sutures are needed. Prior to completing the anastomosis the position of the stent is checked radiologically. A small silastic drain with perforations is left in the vicinity of the anastomosis exiting through the port in the hypogastrum.

Post-operatively, the patients are placed on a clear liquid diet. The Foley catheter is generally removed on post-operative day 2 and the drain removed the next day if the drainage is low. Patients return for stent removal in 4-6 weeks in the operating room.

We recently reviewed our experience with primary laparoscopic pyeloplasty (LP). Fifty-six patients underwent LP; of these 40 were male and 16 female with an average age of 53.6 months and average weight of 20 kilograms. Intraoperatively, 51/56 (91%) had a retrograde ureteropyelogram, while 55/56 (98%) had a ureteral stent placed. The average operative time was 249 minutes. After surgery, the average hospital stay was 3 days with the average catheter duration of 2 days, and average drain duration of 3 days. The stent was removed on average after 39 days. Patent of the anastomosis was seen in 55/56 (98%) at an average follow-up of 7 months. Complications included: redo LP for recurrence (1), nephrostomy dislodgement (1), stent replacement (1), ileus (2), and vascular injuries treated laparoscopically (2). None of the patients required an open conversion.

We have currently adopted laparoscopic pyeloplasty as our standard treatment for primary as well as redo-pyeloplasty with great success. We hope that the lessons we have learned will help decrease the learning curve for those pediatric urologists interested in the transition from open to laparoscopic pyeloplasty.

**References**

Complete Intracorporeal Laparoscopic Enterocystoplasty

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Introduction
Despite the widespread introduction of laparoscopic procedures in pediatric urology, augmentation cystoplasty is still performed in an open fashion at most institutions due to the perceived intricacy and demanding nature. Herein we describe our technique for complete intracorporeal laparoscopic enterocystoplasty, following with a discussion about surrounding innovations and possible complications, based both on our experience and outside reports.1,2

Contraindications
Contraindications to complete intracorporeal laparoscopic enterocystoplasty are similar to those found in an open fashion. However, in addition, a history of prior major abdominal or pelvic operations may also pose a contraindication, although intra-abdominal adhesions can be released to some extent. Minor previous procedures, such as cecostomy tube or upper abdominal surgery, are not found to be relative contraindications.

Preoperative Preparation
Poorly prepared bowel places the patient at an increased risk for a large intraperitoneal spill and any of its potential associated serious consequences; therefore, full mechanical and antibiotic preoperative bowel preparation would be imperative. Although a recent report has suggested that bowel preparation is unnecessary for cystoplasty in children3, our protocol for laparoscopic procedures involving bowel would be to reduce the bacterial load as much as possible, according to the current standards of care.

Surgical Procedure
The patient is placed supine with the legs slightly apart and a Foley catheter is inserted. We put ureteral stents to initially identify the ureters, thus to avoid ureteral injuries. However, since it is not an essential process for laparoscopic enteroplasty, recently ureteral stents have not been placed. A total of three ports are placed with the configuration shown in Figure 1. In brief, a 12-mm trocar is inserted at the umbilicus. After achieving adequate intraperitoneal pressure, a 12-mm trocar in the right upper quadrant and a 5-mm trocar in the left upper quadrant are inserted at the mid-axillary level (Figure 1).

A premeasured 15-cm vessel loop segment is used for the estimation of the distance appropriately. To select the segment of bowel, attention is paid to the distance of the loop from the ileocecal valve and the mobility of its mesentery, which should allow for tension-free advancement toward the pelvis. The points of excision are demarcated by placement of percutaneous sutures as fixing sutures to the abdominal wall using a Keith needle; providing an easy visual aid to identify these points (Figure 2). Using the laparoscopic light, identification of the mesenteric vessels is made easier and mesenteric windows are then developed with the assistance of the laparoscopic hemostatic cutting devices. The segments of bowel are transected with endoscopic gastrointestinal anastomosis staplers (Endo-GIA), and subsequently bowel continuity was restored with a side-to-side anastomosis using the stapler device and intracorporeal free-hand sutures as in open surgery.

Technical Innovations
As we described above, laparoscopic augmentation cystoplasty closely mimics the time-honored open counterparts. However, application of some technical innovations is required to perform complete intracorporeal laparoscopic enterocystoplasty.

Figure 1: A 12-mm trocar is inserted at the umbilicus. A 12-mm trocar in the right upper quadrant and a 5-mm trocar in the left upper quadrant are inserted at the mid-axillary level.

Figure 2: Transabdominal fixating sutures are placed through the abdominal wall and the structure of interest. A) A blue suture (black arrowheads) indicates an isolated ileal loop for augmentation cystoplasty and a white suture (white arrowheads) for anastomosis. B) Both fixing sutures are secured outside the abdominal wall. This relatively simple maneuver keeps the proper orientation of the ileum and the tension, and secures the anatomic structure of interest to prevent kinking and twisting of the mesentery.

After the isolated ileal loop is irrigated in situ with the laparoscopic suction irrigation with antibiotic solution, the bowel is opened on its antimesenteric border, using the laparoscopic hemostatic cutting devices. The U-shaped reconfiguration of the detubularized patch is achieved by securing the apex to the anterior abdominal wall and expedited by intracorporeal free-hand sutures or the use of the Endo-Stitch Autosuture device.

A running anastomosis with the bladder and detubularized ileal patch can be achieved by either intracorporeal free-hand sutures or the use of the Endo-Stitch Autosuture device under direct visualization. A watertight closure is then verified by irrigating with sterile saline through the Foley catheter. Either port can then be used to advance a closed suction drain near the anastomosis.

Technical Innovations
As we described above, laparoscopic augmentation cystoplasty closely mimics the time-honored open counterparts. However, application of some technical innovations is required to perform complete intracorporeal laparoscopic enterocystoplasty.

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Measurement of the ileum: Since visual estimation of the bowel may be inaccurate, a premeasured vessel loop segment to measure the length of the ileum helps rapid and accurate estimation of the distances.

Fixing suture: At multiple points during the procedure, transabdominal fixating sutures are advanced percutaneously (Figure 2). These sutures are placed through the abdominal wall and the structure of interest, a process that can be accomplished with a Keith needle. This relatively simple maneuver keeps the proper orientation of the ileum and the tension, and secures the anatomic structure of interest to prevent kinking and twisting of the mesentery. This also has the advantages of easy relocation, depending on changes in the angle of dissection, as well as allowing the surgeon to complete the procedure with fewer trocars. Furthermore, because the need for an assistant to help with positioning and exposing structures during the case is not necessary, the use of these anchoring sutures provides a greater degree of movement, not only inside the abdominal cavity, but also around the patient, an important consideration in pediatric patients.

Suturing: Although intensive suturing and intracorporeal tying are required in this surgery, suturing and tying are often the most difficult and time-consuming procedures in laparoscopy. The Endo-Stitch Autosuture might be helpful in creating the ileal patch and suturing the patch to the bladder. However, those procedures can be achieved adequately by free-hand suturing of experienced hands. Therefore, extensive experience with laparoscopy is necessary before attempting laparoscopic augmentation cystoplasty.

Possible Complications

General complications related to laparoscopy, such as injury from Veress needle or trocar insertion, port site hernia and thromboembolic phenomena etc., have been previously well described. Bowel manipulation can be time-consuming during laparoscopy compared to open procedure. Although potential complications specific to the ileal manipulation under laparoscopy include ileus, bowel stricture, anastomosis stricture, etc., the laparoscopic approach may minimize some of these problems compared with open procedures. Additionally adherence to basic surgical principles during surgical reanastomosis should yield results comparable to the open anastomosis.

In conclusion, pure laparoscopic enterocystoplasty in children is an advanced procedure that is technically demanding. Although it appears feasible and provides a minimally invasive option to bladder augmentation, its equivalency or superiority over laparoscopic assisted or conventional open techniques remains to be demonstrated.

References

The Role of Robotics in Pediatric Urology

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Introduction

As with free-hand laparoscopy, robotic-assisted laparoscopy (RALS) has been gradually incorporated over time as a tool for pediatric urologists. Numerous case reports have been published and after this initial enthusiasm, more mature and prospective studies are appearing with increasingly thoughtful analysis. The most common robotic procedure in pediatric urology is pyeloplasty. Other procedures such as ureteral reimplantation, both intra- or extravesical, nephrectomy (including partial), ureteroureterostomy, pyeloureterostomy, pyelolithotomy, and appendicovesicostomy have been described, among others. Our aim is to describe the principles of the basic techniques and highlight specific points and their outcomes.

Kidney Surgery

Most renal surgery beyond a simple nephrectomy appears to be well-suited for robotic use in which the advantages of vision and dexterity are of value, in contrast to conventional laparoscopy. Even simple nephrectomy is benefited with the robotic system to provide careful access to and control of the hilum.

Technique

Proper trocar placement is critical for efficiency. Most renal procedures can be performed with a similar port placement and access. Port placement as evolved and improved over time. In children there is no specific distance needed between ports, providing that a symmetric layout is afforded. If the area that we need to work in is small, we can place the ports closer. For example, a pyeloplasty in an infant may have ports as close as 2 inches due to the small abdominal size, while in a teen, the distance may be two times that. We have not been limited significantly by age, and children as young as 3 months (about 7 kg) have undergone successful robotic pyeloplasty. The key element in port positioning is symmetric alignment about the central camera axis, and a recognition of the working room requirements of the cannulae and instruments. If the port entry is too close to the area of interest, movement is limited.

The 12 mm camera port is placed in the umbilicus followed by a 5 or 8 mm working port midway between the umbilicus and the xyphoid. The patient is then rotated to raise the ipsilateral side and the dilated renal pelvis or kidney is identified. The position of the UPJ (for pyeloplasty) is used to determine the position of the inferior working port so that it is symmetric with the upper working port with the camera oriented toward the area of surgery. With large renal pelvis or smaller children, the inferior port will need to be more inferior and medial.

For pyeloplasty, the pelvis is exposed transmesenterically on the left side when visible or after reflecting the colon. Often the ureter is first identified and guides the exposure of the pelvis. Subsequently, the ureter and renal pelvis are mobilized and a hitch stitch is placed through the abdominal wall and passed through the upper part of the pelvis and re-passed through the abdomen. It is then snapped at the appropriate degree of tension to maintain stability of the UPJ and lift it from the inevitable puddle of urine and blood. The pelvis is transected and used as a handle for the ureter during spatulation and anastomosis, and eventually removed. The anastomosis is performed with absorbable suture ranging from 7-0 to 5-0 depending on patient size. Ureteral stenting is advisable, either placed retrograde before the procedure (with or without an extraction string), or antegrade during the repair. A percutaneous nephroureteral stent can also be used but is more difficult to place. A bladder catheter is left in place overnight.

Outcomes

Initial results of pyeloplasty have been reported and appear to be similar to open surgery with 95% success.\(^1,3\) No significant intra-operative complications have been reported in these three series. Reoperative cases have been undertaken successfully as well.\(^4\)

Partial nephrectomy has been performed with a similar set-up as for pyeloplasty, but the renal hilum must be fully exposed for adequate vascular control. We have chosen to use a fourth port to provide retraction of the liver on right-sided procedures. The ability to close the renal defect with mattress sutures provides an advantage over conventional laparoscopic methods, and may limit the occurrence of urinoma.

Ureteral Surgery

Few reports have been published utilizing RALS to correct ureteral abnormalities. Ureteroureterostomies for calculi, uretero-folds, retro-caval ureters and other uncommon pathologies would all be readily amenable to robotic procedures. In the setting of duplication anomalies, uretero-ureterostomy or ureteropelvostomy have been performed with good success using a similar surgical plan as pyeloplasty. Even when upper pole function is limited, a simple drainage procedure may be more efficient than a partial nephrectomy. Outcomes have been good and without complications.

Pelvic Surgery

In infants, several procedures can be performed robotically in the pelvis, particularly extravesical ureteroplasty for reflux, and including intravesical ureteral reimplantation, urachal resection and Mullerian cyst excision.

Technique for Extravesical Ureteral Reimplantation

The most common anti-reflux procedure reported has been the extra-vesical Lich-Gregor. Similar port placements are used for other pelvic procedures as this provides optimal exposure of the retrovesical space. The camera port is placed in the umbilicus and the two working ports are placed in the mid-clavicular lines at about the level of the umbilicus. This port placement is favorable for treating either one or both ureters. The ureter can be seen just outside the bladder and the peritoneum lying on top is incised transversely behind the bladder. The ureter is dissected and traction is placed until the hiatus is exposed. A holding suture facilitates bladder stabilization and exposure of the hiatus. The bladder muscle is incised with cautery to create the detrusor tunnel. While it would be ideal to spare any neural structures in this area to limit the risk of post-operative retention, the ability to recognize these structures remains uncertain in our experience. Care must

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be taken to ensure the tunnel is of adequate length. Sometimes, the magnification provided by the robotic system may overestimate the tunnel length. This may be one cause for the persistence of reflux. Conversely, with the bladder only partially filled, the effective tunnel length may be more than is apparent. The muscle layer is closed over the ureter with interrupted absorbable suture, from the proximal to distal aspect.

Outcomes

There are few reports on extravesical ureteral reimplantation, but excellent success has been noted without post-operative retention in bilateral cases. Our experience with bilateral extravesical reimplantation has included occasional episodes of transient retention, but we have continued to employ the technique. The published suggestion that VCUG is not needed, however, is premature in this emerging technology. No complications have been reported. Intravesical reimplants also have been reported with adequate outcomes. Whether these procedures afford a significant benefit over open or endoscopic surgery remains undefined as even open procedures are being performed on a day-surgery basis. It is uncertain if currently available outcomes parameters are sensitive enough to detect any appreciable differences. The few reports on excision of Mullerian remnants and ureteroplasty have shown good outcomes without complications.

Horizons

More complex reconstructive procedures are being explored tentatively, and initial reports are encouraging. Continent diversion, ileal augmentation and bladder neck sling, as well as pyeloplasty have been attempted. The future evolution of robotic surgery in pediatric urology is yet to be defined, but is likely to offer safe, efficient, minimally invasive surgical options for a wide variety of procedures. The determination of benefits will require more robust outcome parameters that reflect patient morbidity, both physiologically and perceptually. The valuation of those benefits, however, is not likely to be determined by the pediatric urology community. With the inevitable innovations in technology, the capabilities of robotic surgery will increase as cost decreases. It will be important that the pediatric urology community participate actively in this evolution to ensure that it is applicable to children.

Conclusions

Overall, robotic-assisted laparoscopic procedures in pediatric urology have been performed safely and effectively with a shorter learning curve than conventional laparoscopy. Ongoing experience will improve surgical techniques and the likely technological evolution will permit even more utility.

References


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