Chapter 2

Instrumentation During Pediatric Robotic Anastomoses and Reconstruction

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Introduction

For the past four decades, patients have increasingly chosen the minimally invasive option for their urologic surgical needs to avoid the morbidity of large incisions, and this generally has led to shorter hospital stays, less pain medication requirements, and earlier return to normal activity levels in adult patients. This is especially true for adult patients who have undergone ablative urologic procedures such as nephrectomy or adrenalectomy by conventional laparoscopic techniques. The advantages of minimally invasive surgery also apply to pediatric patients and especially for those who have undergone ablative pediatric urology procedures with similar benefits seen in these patients. Of note, the first reported use of laparoscopy in pediatric urology was for patients with nonpalpable undescended testes in the 1960s [1], and diagnostic laparoscopy in this setting has gained widespread acceptance among pediatric urologists. Over the last two decades, laparoscopic surgical techniques have improved significantly in the adult and pediatric patient populations since the first reported laparoscopic pyeloplasty in the adult population in 1993 [2] and the first pediatric laparoscopic pyeloplasty in 1995 [3], both by the use of conventional laparoscopy. In children, this has led to a reliably safe and effective approach to the kidney for reconstructive urological procedures that require extensive suturing with similar success rates and potential benefits with regard to cosmesis, intraoperative blood loss, postoperative stay, and the length of the overall hospital stay.

However, for pediatric urology cases, the limitations of conventional laparoscopic equipment and the steep learning curve associated with its use in pediatric reconstructive procedures have led to only a modest adoption among pediatric urologists for these types of procedures. The da Vinci Surgical System from Intuitive Surgical (Sunnyvale, CA) has introduced the benefits of an intuitive interface, three-dimensional visualization, and greater degrees of instrument articulation and control that allow for robotic-assisted laparoscopic procedures. The increased precision of and facility with instrumentation offered by robotic assistance is readily seen in pediatric procedures, specifically those that are reconstructive in nature, and thus require extensive dissection and suturing. This has helped to increase the utilization of minimally invasive techniques for pediatric reconstructive procedures.

The most commonly performed robotic procedures in the pediatric population to date are pyeloplasty and extravesical ureteral reimplantation [4]. As technology has advanced, with finer degrees of control and ever-improving visualization through smaller and smaller cameras, the use of robotic-assisted laparoscopic surgery in pediatric urology should continue to rapidly

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increase, as more surgical techniques are adapted to the robotic-assisted laparoscopic option. The close approximation of these techniques to their open counterparts facilitates the transition to the minimally invasive option. In this chapter, we will describe the robotic instrumentation available for use with the Da Vinci surgical robot and discuss its advantages in various procedures in the field of pediatric urology.

The Da Vinci Surgical System

The Da Vinci Surgical System from Intuitive Surgical (Sunnyvale, CA) consists of a surgeon console, a patient-side cart with the interactive robotic arms (the “robot”), a vision cart (the “video tower”), and the proprietary *EndoWrist* robotic instruments. Since its approval for clinical use by the US Food and Drug Administration in 2000, the Da Vinci surgical robot has greatly expanded the field of minimally invasive surgery in the field of urology, and most notably in the surgical management of prostate cancer. For men diagnosed with localized prostate cancer, robotic-assisted laparoscopic prostatectomy has become a widely performed procedure in the USA as both patients and surgeons have rapidly adopted this minimally invasive surgical alternative to open surgery. In addition, the Da Vinci surgical robot has gained acceptance for pediatric urology procedures as the technological advances appear to be particularly useful for the reconstructive nature of most pediatric urologic procedures.

The patient-side cart with the robotic arms consists of up to four working arms, although the fourth arm is seldom used in the pediatric population because of the smaller working spaces in pediatric patients. In addition, avoiding the fourth arm can reduce the initial capital investment required for the system. The three main robotic arms consist of the camera arm and two instrument arms, where each arm is attached to their respective laparoscopic ports. The middle camera arm is specifically designed to hold the system’s camera telescope, while the two side arms control the robotic instruments, which are inserted and removed by the bedside assistant.

The camera arm consists of two cameras in a single metallic sheath and is designed to mimic the binocular function of a surgeon’s eyes. The signal from each of the two cameras is delivered to the surgeon console, which processes the two images to provide the surgeon with a single three-dimensional image. This provides the surgeon with superior surgical visualization during the procedure due to the 10-fold magnification and the sense of depth perception that is not seen with conventional laparoscopy.

The surgeon console is a distinct unit at which the surgeon is comfortably seated while handling the robotic controls. The degree of control includes arm position, focus, zoom, camera position, and instrument movement, with a relatively short learning curve before one becomes comfortable with the controls. The motion control is enhanced by the console system, which can translate the surgeon’s precise movements and imbuing fluidity of action to the surgical field, while dampening any potential hand or arm tremors. This novel control system has the potential for future ergonomic benefits for surgeons, which most likely will be shown as robotic experience among surgeons grows.

The robotic instruments have proprietary “EndoWrist” articulation that allows for more precise control and improved manipulation of tissue than is offered with standard laparoscopic instruments. It mimics the seven degrees of freedom present in human wrist articulation and therefore gives the console surgeon the ability to perform precise finite movements with the robotic instruments. This close approximation to a surgeon’s movements during open surgery has the potential for shorter learning curves with this minimally invasive modality as opposed to previous minimally invasive options.

In summary, the Da Vinci Surgical System’s combination of robotic technological advances, magnified visualization, and precise operator control has led to a transformation of standard open surgical techniques in children for pediatric urology procedures to their minimally invasive counterparts, where these procedures can now be performed via small laparoscopic incisions instead of a large open incision.

Instruments

A wide range of instruments are available for the Da Vinci robotic surgical system which approximate those used in both open surgery and traditional laparoscopy. Common instruments in open surgery and laparoscopy, such as needle drivers and Maryland dissectors, have robotic counterparts that were created for use with the Da Vinci system. The most obvious advantage of these newly adapted instruments over their laparoscopic predecessors is the presence of the articulating EndoWrist technology as previously described, which increases the flexibility of the instrument tips and thus augments the instrument's utility by making it possible to approach and grasp tissue from many different directions, as opposed to the plane directly accessibly by the port. This in turn allows for more effective traction and tissue exposure, as the instrument's movement is similar to the surgeon's hand and wrist movements, as opposed to traditional laparoscopy where a surgeon's movements are opposite to those of the internal instruments.

The camera telescope with three-dimensional visualization is available in two sizes: 12 and 8.5 mm. A 5-mm camera telescope is also available but is limited to two-dimensional visualization as seen in conventional laparoscopy since this telescope contains a single camera. For the robotic instruments, a wide range of instruments are currently available in both 8 and 5 mm sizes. However, certain instruments are currently not available in the 5 mm size, and this includes the electrocautery-capable monopolar curved scissors (Hot Shears). Despite this limitation, with the goals of improved cosmesis and smaller skin incisions in mind, we utilize the 8.5-mm telescope and the 5-mm instruments for the majority of our pediatric robotic procedures, where the 12-mm telescope and the 8-mm instruments are reserved for adolescent patients. In general, the 5-mm instruments have a longer articulating tip than the 8-mm instruments; however, we have not experienced any negative sequelae with the use of the 5-mm instruments during robotic procedures in children.

A number of instruments in particular are useful for the pediatric surgical specialist. The initial dissection during a typical procedure is dependent on a combination of blunt dissection and dissection with cautery; this is especially apparent in the exposure of the kidney and the renal pelvis, as tissue planes are well defined and often can be bluntly developed initially. We recommend the use of a cautery instrument in the right hand and a grasping instrument in the left hand.

The most commonly used monopolar cautery device in the 5 mm size is the monopolar cautery instrument with either a hook or a spatula tip (Fig. 2.1), since the monopolar curved scissors (Hot Shears) are available only in the 8 mm size. Advantages of the monopolar cautery hook include its capability for blunt dissection near potentially delicate posterior structures prior to the initiation of cautery, as well as its small contact focus of cautery, which allows for precise incision and exposure of tissue planes with the blunt tip of the instrument. The monopolar curved scissors (Hot Shears) can provide sharp dissection with a smaller contact focus of cautery as compared to the monopolar cautery hook; however, its capability for blunt dissection may be limited due to the sharp edges at the scissors' distal tip, as well as to its sole availability in the 8 mm size. Another alternative for a cautery

Fig. 2.1 Monopolar cautery hook—5 mm

instrument are the harmonic curved shears, which are available in 5 and 8 mm sizes. As with the laparoscopic harmonic instruments, the cautery energy is transmitted between the jaws of the device, and this containment of energy may help to avoid inadvertent cautery injury to surrounding structures.

A variety of grasping instruments are available for the Da Vinci robot for pediatric procedures. Routine forceps and graspers in the 5 mm sizes include the Maryland dissectors (Fig. 2.2) and the DeBakey forceps (Fig. 2.3). If a larger grasper is required, the atraumatic bowel graspers (Fig. 2.4) and the sharp-toothed Schertel graspers are available in the 5 mm sizes for creating and maintaining surgical exposure. As with the cautery instruments, other graspers and forceps are available that can provide more forceful traction, such as the ProGrasp forceps. But they are available only in the 8 mm sizes and thus may have limited utility for pediatric procedures. Unfortunately, the bipolar Maryland forceps are also available only in the 8 mm size, and this may be one instrument that, if available in the 5 mm size, could help to increase surgeon's efficiency and reduce operative times in pediatric procedures, as many robotic surgeons use the bipolar Maryland forceps as their grasping instrument. This allows the use of bipolar cautery in the grasping instrument without the need for an instrument change. The combination of finite movements with the Maryland forceps with the added ability to deliver hemostasis with the use of bipolar energy would be beneficial in pediatric cases.

For cutting purposes, only two types of scissors are currently available in the 5 mm size: curved scissors (Fig. 2.5) and round-tip scissors. In most instances, the curved scissors are useful for general dissection and cutting. However, certain procedural steps, such as the spatulation of a ureter prior to a dismembered pyeloplasty anastomosis, may necessitate a straight incision with the round-tip scissors. The relatively wide distal tips of the round-tip scissors may limit its usefulness for small-caliber ureteral spatulations. For fine-cutting purposes, Potts scissors with sharp pinpoint tips are available, but only in the 8 mm size.

For pediatric procedures, the needle driver (Fig. 2.6) and the 5-mm grasping instruments listed above are usually sufficient for suture placement and knot tying in an instrument-tie manner. In general, one is advised to handle reuseable portions of the suture with the needle driver as opposed to the grasping instruments, since the needle driver tends to better preserve

Fig. 2.3 DeBakey forceps—5 mm

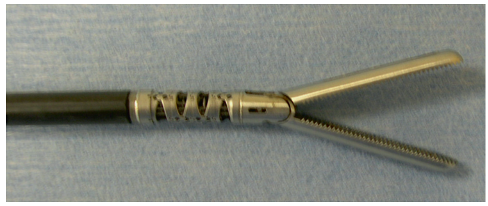

Fig. 2.4 Bowel graspers—5 mm

Fig. 2.2 Maryland dissector—5 mm

Fig. 2.5 Curved scissors—5 mm

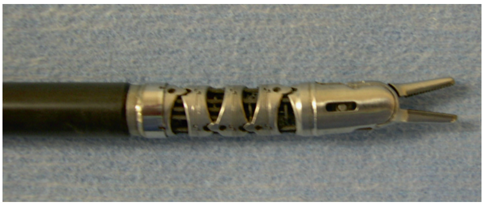

Fig. 2.6 Needle driver—5 mm

the suture integrity when handling a suture. A larger variety of other instruments are also available, but only in the 8 mm size. Instrument ties with the Black Diamond microforceps may be facilitated by the instrument's narrow tips, as it is easier to wrap the suture around the narrow tips of these forceps. Another instrument available only in the 8 mm size is the SutureCut needle driver, which has a small scissor blade in the base of the instrument's tips that can be used for cutting suture without the need for an instrument change or an assistant. One must take care not to prematurely cut one's suture. Future technological advances may allow for these instruments to become available in the 5 mm sizes.

In addition to the wide variety of robotic instruments available with the proprietary "EndoWrist" articulation, the pediatric robotic surgeon also has the ability to use traditional laparoscopic instruments either through one of the robotic instrument ports or through an accessory 5-mm laparoscopic port. We generally encourage the use of a 5-mm accessory port to potentially increase surgeon's efficiency and to reduce operative times. Attaching the CO_2 gas inflow to the accessory port may also decrease the incidence of poor camera visualization due to fogging. In addition, the accessory port can also provide the capability for the bedside assistant to assist with retraction, suture placement and removal, as well as suction and irrigation without the need for an instrument change. Furthermore, the entire gamut of laparoscopic instruments such as clip appliers and scissors can be utilized during the robotic procedure. And the accessory port can serve as the conduit in which to place ureteral wires and stents into the ureter without the need for a separate incision or puncture.

As robotic technology continues to evolve, the list of robotic instruments is expected to grow with miniaturization of the instruments and improved surgeon's capabilities in the robotic setting. This should be especially beneficial for the pediatric urologic patient where an increasing number of pediatric reconstructive procedures can be performed in a minimally invasive fashion with the potential for clinical benefits such as improved cosmesis, decreased hospital length of stays, and reduced pain medication requirements. In the next paragraphs, several robotic procedures in pediatric urology are described with respect to their instrumentation needs.

Robotic-Assisted Laparoscopic Pyeloplasty

Pyeloplasty for the surgical management of ureteropelvic junction (UPJ) obstruction is one of the most common uses for the Da Vinci robot in the pediatric urology field. UPJ obstruction is more commonly being diagnosed in the perinatal period due to early detection with antenatal ultrasound imaging, as opposed to later in childhood or even adulthood for symptomatic manifestation [5]. Accompanying this trend is the rising concern that prenatal diagnosis of UPJ obstruction can lead to anxiety in expecting parents with worries that their newborn will require surgical intervention early in life [6]. For this reason, minimally invasive modalities for the surgical management of UPJ obstruction in infants and children may help to alleviate the concerns of parents by giving them a less invasive surgical option rather than open surgery.

Primary UPJ obstruction can be due to intrinsic obstruction with an aperistaltic segment of ureter at the level of the renal pelvis with an interruption of ureteral muscular development leading to contractile discontinuity and functional obstruction [7]; due to high insertion of the ureter into the pelvis; or due to extrinsic compression from a crossing lower pole renal vessel that crosses anterior to the UPJ. Other potential causes of UPJ obstruction include persistent congenital valvular mucosal folds [8] and upper ureteral polyps [9]. Secondary UPJ obstruction can be seen secondary to severe vesicoureteral reflux when the dilated tortuous ureter kinks and impedes urine flow. Initial repair of the UPJ obstruction is generally recommended in these cases [10].

Surgical repair of UPJ obstruction is commonly performed using a dismembered pyeloplasty technique as described by Anderson and Hynes [11]. This technique via an open incision has become the gold standard for UPJ reconstruction as it allows for extensive flexibility in the excision of abnormal ureteral segments, as well as the preservation of aberrant crossing vessels. The laparoscopic adaptation of this technique was first reported in adults in 1993 [2], and subsequently in children in 1995 [3]. With the laparoscopic technique with peritoneal insufflation and direct endoscopic visualization, rapid identification of the obstructed UPJ, as well as the rapid detection of a crossing vessel, if present, is possible. However, one of the limitations of the laparoscopic technique was the steep learning curve for the ureteral reconstruction, which involves extensive laparoscopic suturing and hence has resulted in only a modest adoption by pediatric urologists.

The EndoWrist articulation of the Da Vinci system allows a surgeon to mimic actual hand and wrist movements to help overcome the technical demands of intracorporeal suturing. Robotic-assisted laparoscopic pyeloplasty has been described as a cutting-edge improvement over laparoscopic pyeloplasty [12], with comparable results to open surgery [13]. The 10-fold magnification and three-dimensional visualization appear to shorten the learning curve for surgeons with limited experience in minimally invasive reconstruction [14]. However, the benefit to experienced laparoscopic surgeons may be limited.

Robotic-assisted laparoscopic pyeloplasty has also been shown to be safe and successful in infants [15] and in reoperative cases [16]. When directly compared to open surgery, robotic-assisted laparoscopic pyeloplasty has led to decreased lengths of hospital stays and reduced pain medication requirements, as well as similar operative times when compared to open surgery once a surgeon has gained sufficient experience [17].

Robotic-assisted laparoscopic techniques have also been described for difficult intrarenal collecting systems or for failed pyeloplasties for which successful robotic ureterocalicostomies were performed [18]. In addition, for patients with lower ureteral obstruction, robotic-assisted laparoscopic ureteroureterostomy has been successfully performed in both single and duplicated collecting systems [19].

Useful 5-mm Instruments

Exposure/initial dissection of the renal pelvis in the retroperitoneal space can be accomplished with the *monopolar cautery hook* in the right hand and the *Maryland dissector or DeBakey forceps* in the left hand. The use of *curved scissors* is limited by the lack of cautery in the 5-mm version of this instrument.

Transection of the renal pelvis and the ureter can be performed with c*urved scissors or round-tip scissors. Spatulation* may be facilitated by the straight tips of the *round-tip scissors*; however, the wider tips of these scissors as compared to the *curved scissors* may limit this advantage in small ureters.

Anastomosis may be performed with two *needle drivers* or the use of one *needle driver* and one grasping instrument such as the *DeBakey forceps*, with the caveat that one should preferentially handle reusable portions of the suture with the *needle driver* as opposed to the grasping instruments.

Robotic-Assisted Laparoscopic Renal Surgery

The Da Vinci robot has been used for other types of renal surgeries such as complete and partial nephrectomy, pyelolithotomy, calyceal diverticulectomy, and adrenalectomy in the pediatric population [20]. This should not be surprising given the access to and visualization of the kidney demonstrated in reconstructive procedures such as the dismembered pyeloplasty. The 10-fold magnification and three-dimensional visualization allow for careful identification of key structures in these procedures, which can be difficult to identify in the typical pediatric patient. However, the benefits of robotic surgery over conventional laparoscopy have yet to be demonstrated for pediatric urology procedures that are primarily extirpative in nature.

While robotic-assisted laparoscopic partial nephrectomies in adult patients are common for the removal of small kidney tumors [21], robotic-assisted laparoscopic partial nephrectomies in children are often performed for the removal of benign nonfunctioning upper pole segments. In the small working space of a pediatric patient, the Da Vinci system's optics and fine articulation and instrument control may allow for precise movements and potentially safer procedures. Often, these nonfunctioning upper pole segments have their own vascular supply, which necessitates identification and control of the upper pole blood supply without the need for clamping of the lower pole vascular supply. Hence warm ischemia time is usually not necessary when this procedure is applied to children because of their duplicated vascular anatomy. As with laparoscopic partial nephrectomies, the distinction between the poles is often clearly demarcated, and extensive mobilization of the duplex kidney is usually unnecessary [22].

The surgical procedure for a robotic-assisted laparoscopic partial nephrectomy closely resembles that of the conventional laparoscopic technique. The arterial supply to the nonfunctioning upper pole segment, if located, is clamped to allow ischemic delineation of the borders of the upper pole on the cortex of the kidney. Once the borders are delineated, the ischemic upper pole can be removed with electrocautery or harmonic curved shears similar to the conventional laparoscopic technique [23].

Robotic-assisted laparoscopic partial nephrectomy has been described in the adult population [24], with the adaptation of the robotic procedure to utilize a single laparoscopic port [25]. Robotic-assisted laparoscopic partial nephrectomy has also been reported as a safe option for use in children, with a relatively short learning curve and the potential for enhanced safety and efficiency for this minimally invasive option because of the magnified visualization and fine dexterity of the robotic instruments [26].

Useful 5-mm Instruments

Exposure/initial dissection of the kidney in the retroperitoneal space can be accomplished with the *monopolar cautery hook* in the right hand and the *Maryland dissector or DeBakey forceps* in the left hand. The use of *curved scissors* is limited by the lack of cautery in the 5-mm version of this instrument.

Partial nephrectomy of a nonfunctioning upper pole can be performed using *monopolar cautery hook* or *harmonic curved shears*. If significant upper pole vessels are encountered, laparoscopic clipping or robotic suture ligation may be necessary. Yet in many instances, due to the atretic nature of the upper pole vessels, simple cautery or the use of the harmonic instrument may be sufficient for vascular control.

Hemostasis with mattress sutures, if necessary, may be performed with two *needle drivers*, or the use of one *needle driver* and one grasping instrument such as the *DeBakey forceps*, with the caveat that one should preferentially handle reusable portions of the suture with the *needle driver* as opposed to the grasping instruments.

Robotic-Assisted Laparoscopic Ureteral Reimplantation

Vesicoureteral reflux is commonly due to a primary defect at the level of the ureterovesical junction (UVJ) or may occur secondarily when the normal UVJ is overwhelmed by increased intravesical pressure. Primary reflux is usually related to an inadequate length of the intramural ureter, with a tunnel length that is shorter than the optimal tunnel length-to-diameter ratio of 5:1 reported by Paquin [27].

There are numerous techniques for ureteral reimplantation described in the urologic literature, all of which are associated with excellent success rates. Some are performed with intravesical ureteral dissection and tunnel creation [27, 28], while others are performed extravesically, without violation of the bladder mucosa [29, 30]. One of the most difficult steps in these procedures is accessing the native ureter, especially if an extravesical approach is chosen.

Utilization of the Da Vinci robot provides clear unobstructed views of the posterior pelvis from a cephalad point of view, as similarly seen in established robotic procedures such as the robotic-assisted radical prostatectomy. A transperitoneal approach to the distal ureter is feasible once the overlying peritoneum is safely incised and the ureter is identified. We prefer the extravesical Lich-Gregoir technique where the robotic instruments allow for precise placement of interrupted sutures on the newly created bladder muscle flaps to create a new submucosal tunnel for the reimplanted ureter.

Intravesical approaches are also possible using the Da Vinci surgical system. Olsen noted that the transvesical technique was effective in a porcine model where eight pigs with induced vesicoureteral reflux underwent transvesical placement of the robotic camera and the ports into the bladder after induction of pneumovesicum, with successful Cohen cross-trigonal reimplantations in all specimens [31]. The robotic approach was preceded by conventional laparoscopic transvesical reimplantation in children with subsequent high success rates, but it was noted that smaller bladder capacities were associated with higher rates of complication, namely urinary leakage [32]. More recently, robotic-assisted laparoscopic intravesical ureteral reimplantation has been safely and successfully performed in children at several pediatric centers [20, 33]. And successful tapering and reimplantation of megaureters have also been reported [20]. Given the advantages of magnified visualization of the distal ureter and bladder, fine instrument control, and facilitated suturing capabilities, robotic-assisted laparoscopic reimplantation may find greater acceptance in the near future among pediatric urologists.

Useful 5-mm Instruments

Exposure/initial dissection of the distal ureter in the perivesical space can be accomplished with the *monopolar cautery hook* in the right hand and the *Maryland dissector or DeBakey forceps* in the left hand. The use of the *monopolar cautery hook* is especially advantageous as the ureter can be retracted with the hook instrument with minimal risk of ureteral injury. The use of *curved scissors* is limited by the lack of cautery in the 5-mm version of this instrument.

Creation of the bladder muscle flaps may best be accomplished with the use of the *monopolar cautery hook* due to the lack of cautery with the 5-mm *curved scissors*. Bladder distension via the Foley catheter may assist with this dissection and may help prevent bladder mucosal perforation.

Closure of the muscle flaps over the ureter to complete the extravesical reimplantation may be performed with two *needle drivers*, or the use of one *needle driver* and one grasping instrument such as the *DeBakey forceps*, with the caveat that one should preferentially handle reusable portions of the suture with the *needle driver* as opposed to the grasping instruments.

Robotic-Assisted Laparoscopic Bladder Surgeries

Other procedures in the field of pediatric urology to which robotic assistance has been applied involve the urinary bladder, with the greatest benefits seen in procedures requiring extensive laparoscopic suturing. In the pediatric population, children with neurogenic bladder related

Table 2.1 Common instruments in pediatric robotic urologic surgery

- Monopolar cautery hook or spatula (5 mm; 8 mm) (Fig. 2.1)
- Maryland dissector (5 mm; 8 mm with bipolar) (Fig. 2.2)
- DeBakey forceps (5 mm; 8 mm) (Fig. 2.3)
- Bowel grasper (5 mm; 8 mm) (Fig. 2.4)
- Round-tip scissors (5 mm; 8 mm)
- Curved scissors (5 mm—without cautery) (Fig. 2.5)
- Needle driver (5 mm; 8 mm) (Fig. 2.6)
- ProGrasp forceps (8 mm only)
- Harmonic curved shears (5 mm; 8 mm)
- Monopolar curved scissors (Hot Shears) (8 mm only)

to their myelomeningocele represent a group of patients that may require bladder augmentation with lifelong catheterization, either through their native urethra or through a catheterizable appendicovesicostomy [34]. Limited application of minimally invasive techniques to these types of procedures may be in part due to the extensive suturing required for these types of reconstruction. Previous reports of laparoscopic reconstructions include the extracorporeal creation of a neobladder after laparoscopic radical cystectomy [35], although intracorporeal diversions have also been successfully performed with conventional laparoscopy in the porcine model [36].

With the goal of pediatric applications in mind, complete intracorporeal robotic-assisted bladder augmentation was successfully performed in a porcine model [37]. Furthermore, clinical applications of the Da Vinci robot for reconstructive bladder procedures have been described including intracorporeal augmentation with Mitrofanoff appendicovesicostomy [38], antegrade cutaneous colon tube creation [39], and urachal cyst excision with bladder reconstruction [40].

Another potential benefit of robotic-assisted laparoscopic surgery is the potential for combined surgical procedures to be performed in children in a single anesthetic session. Simultaneous robotic-assisted laparoscopic appendicovesicostomy with nephrectomy and orchiopexy was previously reported [41]. This provides new possibilities for patients with multiple urinary tract abnormalities, where robotic-assisted laparoscopic surgery can lead to complete surgical repair of all abnormalities in a single session.

The Future

As robotic technology evolves with improvements and miniaturization of the robotic instruments, more reconstructive procedures in pediatric urology most likely will be performed in a minimally invasive fashion. This should benefit most pediatric urology patients with expected reductions in length of hospital stays, reductions in pain medication requirements, earlier return to normal activity, and improved cosmesis. In addition, one can foresee possible applications of robotic technology to emerging modalities of minimally invasive surgery, such as natural orifice translumenal endoscopic surgery (NOTES), as shown in animal studies using the robotic system [42]. As advocates for pediatric health, pediatric robotic surgeons should strive to be at the forefront of these emerging technologies to ensure that they are properly applied to the pediatric patient.

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