Applications of Robotics in Pediatric Urologic Surgery

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The availability of practical, clinically approved robotic surgical assist systems for laparoscopy, the da Vinci® (Intuitive Surgical Inc., Sunnyvale, CA) and Zeus® (Computer Motion, Santa Barbara, CA) systems, opened a door that was only ajar for reconstructive laparoscopy in pediatric urology. The technology is novel and expensive, yet the initial results and experience justify an enthusiastic continuance of its development and application in pediatric surgical practice. With increasing familiarity with its potential, its applications have broadened to more than a dozen types of procedures. This chapter will review the current use of robotic-assisted procedures in pediatric urological practice, and provide an early assessment of the strengths and limitations and speculation as to the future directions.

The principle advantages of the most commonly used system, the da Vinci® system, is in the provision of precise and delicate movements in a laparoscopic platform under exceptional visual control. The need to compensate for laparoscopic paradoxical movement is no longer present and the precision with which movements may be made is clearly better than conventional laparoscopy. While it might be said that some laparoscopic surgeons are able to suture delicate tissues equally well, there are very few pediatric urologists who have developed those skills. The application of laparoscopic pyeloplasty 10 years after its description by a very limited number of surgeons is evidence that difficulty. With the ability to scale movement and filter tremor, the surgical precision is excellent. What its limits might be remain to be determined, but studies have been published reporting its use in vasovasostomy using 9-0 and 10-0 suture. The visual guidance in three dimensions provides a level of enhancement over laparoscopy that must be experienced. Two-dimensional (2D) imaging is workable, but once the clarity and richness of three-dimensional (3D) imaging are experienced in the surgical field, it is difficult to compromise with only two dimensions. With this enhanced visualization is likely to come enhanced surgical capacity and outcomes, although this remains to be proven.

There are several challenges in the child that must be understood and anticipated in the application of robotic assistance. The wide range in size of the patients requiring surgery makes it difficult to have uniform equipment or setup procedure for these systems and a flexible approach is needed. Similarly, the anatomic orientation of the kidney, for example, may be different and require modification of port site placement. The size of the cannulae and instruments appear very large in the context of small children, yet it should be recalled that early efforts in pediatric laparoscopy were limited to 10-mm cannulae and while they were large, it did not appear to make a large difference in the outcomes of the patients. Similarly, there is a natural evolution of technologies and already we have 5-mm instruments for the da Vinci® system and it would be possible to reduce these further if the need appears. The camera port remains large at 12 mm and this is best hidden in the umbilicus, rather than in the abdomen. It becomes unnoticeable after one to two months. The working ports remain noticeable for several months but eventually fade and
leave minimal scarring. There is no information on the psychological impact of these small scars, but it is important to recognize that scar size is not the principle rational for laparoscopy.

The smaller working space in the child requires consideration in port placement and operative strategy. With the robotic cannulae, there is a specific amount of the cannula that must be within the abdominal cavity to permit the point of no movement (the virtual center) to be at the abdominal all. Even with 5-mm instruments, this is a long distance and puts the tip of the cannula closer to the working area. With the working instruments in place, the articulating segment must be wholly out of the cannula to prevent restriction of movement. This puts the tip even further towards the working area. In the small child this may be past the point where the instrument needs to be used. Therefore, the port entry sites must be further away from the actual operative area. For bladder or pelvic procedures, this means higher in the abdomen; for renal procedures, they must be nearly to the midline. This positional adjustment needs to be done without sacrificing the symmetric arrangement of the port around the endoscope. In practical terms this is an issue in children under nine months. Similarly, the endoscope cannula, which does not have a marked virtual center, cannot be placed too far into the abdomen or the field of vision will be very limited.

During procedures, even with these adjustments, it can be found that as the work moves away from the midpoint between the instruments, the proximity of the tip of the cannula becomes a limiting factor. Often this is during mobilization of the colon for renal exposure. In these cases, it is useful to use the instruments in a crossed fashion so that the holding instrument is the one in the lower quadrant and very close to the action, but it is moved upward, retracting the tissue, and the upper instrument crosses it, performing dissection. This way, both instruments are moving away from their respective cannulae.

Handling tissues requires recognition of the forces generated by the robotic instruments and caution must be taken to avoid directly grasping any functionally important structures directly. Lifting by the adventitia or scooping will reduce the chance of crush injury. Traction sutures are very useful when carefully placed to provide exposure and stability while removing tissue from areas with pooled blood or urine. A well-placed traction stitch will also facilitate access to particular areas, such as the ureterovesical junction. Any traction stitch must be positioned so as to avoid entanglement with the other instruments and sutures. It may be placed through the abdominal wall and brought back out, permitting adjustment of tension. A traction stitch may be tied to another structure, often the internal abdominal wall, but this limits the tension adjustment. A simple short segment of suture tied to the tissue can be used to allow movement without crushing during a procedure, as well.

A final concern regarding use of the da Vinci® robotic system in children is the very large relative size of the device to the child. It may be difficult to even see, let alone access the patient when the robot is engaged. Both the surgical and anesthesia teams must be aware of this and have clearly established paths of access to the patient established before the procedure commences. This facilitates periodic assessment of the patient and the ability to rapidly get to the patient if the need should arise. Consideration for emergency procedures, such as rapid undocking, must also be made between the teams.

23.1. Pediatric Urologic Procedures

The principle procedures for which the da Vinci® system has been used include pyeloplasty, vesicoureteral reflux correction, partial nephrectomy, and nephrectomy. Several other procedures have been performed and reported in limited numbers. The overall experience remains very limited and few comparative studies have been published to date. Most procedures have been previously performed using conventional laparoscopic methods, yet few were used with any frequency, and only by a small group of persistent, perhaps obstinate, surgeons. The robotic device is likely to permit more surgeons to use laparoscopic methods for pediatric urology due to the enhancement of manipulation, particularly delicate suturing; this remains to be seen. While the technical aspects of the major procedures are very similar to the conventional laparoscopic methods, several specific points should be borne in mind.