Review Article

Robotic surgery in pediatric urology

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Abstract

Robotic surgery revolutionized minimally invasive surgery. Urology is the widest surgical field in implementing robotic technology. Pediatric urology followed the footsteps of adult urology in utilizing da Vinci™ surgical system for urinary tract reconstruction. Indeed, day after day robotics is gaining more applications and popularity in pediatric urology due to the need for less invasive approach to reconstruct the urinary tract in pediatric population. In this manuscript, we reviewed in this article the steps of evolution of robotic pediatric urology.

Keywords: Laparoscopy, pediatric urology, robotic

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INTRODUCTION

Laparoscopic reconstructive surgery gained limited popularity in urology due to the challenges encountered by the limited dexterity and the fulcrum effect of the laparoscopic instruments. The introduction of the da Vinci™ robotic surgical system revolutionized minimally invasive surgery by allowing surgeon to perform complicated surgical tasks laparoscopically. The system provides the user with three™ dimensional image and easily controlled laparoscopic instruments, with 7° of freedom, scaling, and tremor filtration. The system works intuitively with the controlling hands and eliminates the fulcrum effect. The surgeon controls the system while seated at a console, with his/her arms rested as if at the operating table. He uses manipulators that transfer his/her movements to the surgical cart, the devices at the end of the working arms. During robotic surgery, the surgeon sits comfortably and looks into a binocular visual system that is fully stereoscopic. In this article, we wanted to shed the light on the evolution of robotic pediatric urology.

MATERIALS

Robotic surgical system facilitated the spread of reconstructive laparoscopy to a wider spectrum of procedures and to larger group of patients. Indeed, soon after the da Vinci™ robotic surgical system was first approved to be used in human in 1999, it invaded the field of urology quickly to the extent that urology became the widest surgical field of utilization of robotics across all surgical specialties.[1] However, the benefits of robotic surgery remained controversial in pediatric urology for a longer time. The cost incurred by robotic surgery the main prohibiting factor for pediatric surgical facility form acquiring the robotic surgical systems.[2]

Children are known to have different physiology and anatomy compared to adults making robotic approach more complicated and challenging compared to open

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technique. It took 3 years for robotic surgical system, since its introduction into human use in 1999, to be utilized in pediatric urology. Robotic-assisted laparoscopic pyeloplasty (RALP) to treat ureteropelvic junction obstruction (UPJO) represents the first expansion of robotic surgical technology into pediatric surgery.[2] After its induction in 2002, RALP has recognized to be combining the merits of minimally invasive approach with an outcome comparable to pure laparoscopic and open approaches.[2] Many early studies demonstrated that no difference in rates of reoperation and complications between the three above-mentioned procedures, yet RALP had a shorter hospital stay, less blood loss, and decreased analgesic requirement.[3] Many subsequent studies demonstrated that RALP has high success rate, shorter hospital stay, and a lower rate of complication compared to other modalities.[4] The high success rate of RALP made it the treatment of choice for UPJO in the centers that possess da Vinci™ robotic surgical system.

After the great success of RALP, pediatric urologists explored utilizing the da Vinci™ robotic surgical system for ureteral reimplantation. Open ureteral reimplantation (OUR) has high success rate yet it requires big surgical incision and followed by large scar. OUR is considered the standard of care when it indicated, however, robotic assisted ureteral reimplantation (RAUR) proved to have a comparable success rate.[5] RAUR as a minimally invasive surgery has proven to be associated with reduced length of stay and postoperative pain.[5] According to multiple reviews, RAUR shows no significant difference in postoperative complications when comparing it to OUR.[6] However, higher rates of bladder spasm, pain, and hematuria were noticed in the OUR cases, making the case for implementing RAUR.[6] RAUR is feasible through transvesical, extravesical, and combined approach. Unlike RALP, RAUR is not considered universally the treatment of choice even in the availability of the da Vinci™ robotic surgical system. It is offered only based on surgeon preference.

Soon after the introduction of RALP and OUR, the da Vinci™ robotic surgical system was utilized for ureteroureterostomy for the same indication of open counterpart, i.e., duplex systems with an upper pole ectopic ureter, obstructed ureterocele, ureteral stricture, etc.[7] In fact, success and complication rates were comparable. However, length of stay and postoperative pain were less in robotic ureteroureterostomy.[8]

Multiple authors reported robotic-assisted appendicovesicostomy and demonstrated its feasibility and success and compared it to the traditional open approach.[9] Unfortunately, not only they reported higher severity of complication, but also lower success rate in the robotic approach compared to open approach.[10] The inferior outcome could have been due to the limited number of cases reported and the learning curve of the reporting surgeons. Moreover, limited number of complex robotic reconstructive procedures were reported and compared to open counterparts to demonstrate feasibility and efficacy. More recent report showed that the functional outcomes and rates of complication in robotic approaches were similar to the open ones with significantly reduced pain and length of stay.[11]

Despite the adoption of the classical laparoscopic technique into many nonreconstructive pediatric urologic procedures, many reports arose in the literature demonstrating the utilization of the da Vinci™ robotic surgical system in pediatric renal surgery. The utilization of near-infrared technology-facilitated partial nephrectomy and heminephrectomy in pediatric population.[12] The long arms and freedom of mobility facilitated by the robotic surgical system expanded its use to perform pediatric nephroureterectomy, especially if it was combined with the need to close the bladder.[13]

For surgeries that require access to the pelvis, and therefore, have a narrow field, may well suit a robotic approach. Excision of seminal vesicle cyst robotically for the first time was reported in 2007.[14] Robotic varicocelectomy was demonstrated to be safe and feasible in 2009.[15] However, it took longer time and was more expensive when it compared to the standard laparoscopic approach.[15] Christman and Casale reported on robotic-assisted bladder diverticulotomy in 2012 with excellent outcome.[16] Then, robotic-assisted excision of urachal anomalies was demonstrated with great success.[17] Then, a giant prostatic utricle was successfully removed robotically after failed first attempt of laparoscopic excision.[18] Another report was published in the same year, 2015, about a successful case of utilizing the da Vinci™ robotic surgical system in the treatment of posterior urethral diverticulum in a 4-year-old boy.[19]

Finally, the da Vinci™ SP surgical system was developed as a novel robotic platform for successfully performing "pure" robotic single-site surgery while overcoming the challenges paused by pure laparoscopic single-site surgery difficulties.[20] The system recently received clearance from the Food and Drug Administration and is currently utilized by urologists, colorectal surgeons, and otolaryngologists.[20] Like the predecessor robotic

system, da Vinci™ SP has been first used in adult, and the expansion of its use in the pediatric population will be a matter of time. Indeed, the system was used to perform the first pediatric robotic single-site cholecystectomy. Single-port robotic cholecystectomy was demonstrated to be feasible and safe approach for cholecystectomy in the pediatric population.[21] It will not be a surprise to see more report about broader utilization of the da Vinci SP surgical system at a broader spectrum in pediatric urology as the report of its use in the adult urologic procedure has surged favorably in the recent years. The da Vinci™ SP system has great potential to be used in pediatric surgery and pediatric urology, time will testify.

CONCLUSION

Pediatric urology will continue to utilize robotic technology in the reconstruction of the urinary tract. Robotic surgery has proven to be effective minimally invasive in the reconstruction of pediatric urinary tract and the treatment of some of the pediatric urologic disease. Robotic technology is evolving and gaining more popularity as it continues to prove its safety and efficacy. The adoption of robotic surgery will continue to increase overtime.

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Conflicts of interest
There are no conflicts of interest.

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