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Original Article

Application in robotic urologic surgery

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Abstract

Background: The da Vinci robot system has become the mainstay of minimally invasive surgery and has been used in numerous complex reconstructive procedures. Due to the success of this innovative technology, we attempted to expand our practical model and application of the da Vinci robot system into other urologic surgeries, beginning with robotic-assisted laparoscopic radical prostatectomy (RALRP).
Methods: We retrospectively reviewed a total of 683 patients who underwent robotic-assisted urologic surgery between December 2005 and December 2012. We divided this 8-year course of device use into three periods, and analyzed the surgical capability of operations in 1 day over different periods through a retrospective analysis.
Results: In the first period (2005—2008), 159 cases of robotic-assisted urologic surgeries were performed. A total of 195 cases were performed in the second group (2009—2010), and 329 cases in the third (2011—2012). Starting with radical prostatectomy in December 2005, we performed various types of procedures such as partial nephrectomy, pyeloplasty, nephroureterectomy with cystoprostatectomy, nephroureterectomy with bladder cuff, radical cystoprostatectomy/cystectomy with ileal conduit reconstruction, partial cystectomy, adrenalectomy, nephropexy, simple prostatectomy, ureteral reconstruction, and pyelolithotomy/ureterolithotomy. The mean operation times of prostatectomy, partial nephrectomy, nephroureterectomy with radical cystectomy/cystectoprostatectomy, and nephroureterectomy were 154, 140, 295, and 129 minutes, respectively.
Conclusion: Based on our experience, a robotic system can be applied to many different types of urologic surgeries both safely and efficiently.

Keywords: application; robotic; urologic surgery

1. Introduction

Robotic surgery has become a worldwide trend over the last decade, and has been successfully used to support numerous minimally invasive surgeries. The da Vinci robotic surgery system (Intuitive Surgical Inc., Sunnyvale, CA, USA) has advantages such as three-dimensional magnified vision, computer filtration of physiological tremors, and EndoWrist instruments with seven degrees of freedom, which taken altogether make intracorporeal dissection and suturing considerably easier. Since the introduction of the da Vinci surgical system into the field of urology in 1999, the robotic system had been used in many different types of urologic surgeries. The first case of robotic-assisted laparoscopic radical prostatectomy (RALRP) at the Taichung Veterans General Hospital (TCVGH) was performed in December 2005. After our medical personnel accumulated sufficient experience using RALRP, we demonstrated that the console time, blood transfusion rate, and complication rate could be reduced significantly.[1,2] We also performed partial nephrectomy, radical nephrectomy, radical cystectomy with/without

Conflicts of interest: The authors declare that there are no conflicts of interest related to the subject matter or materials discussed in this article.

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bladder reconstruction, partial cystectomy, nephroureterectomy with bladder cuff excision, adrenalectomy, nephropexy, and pyeloplasty.

We studied other robotic urologic surgeries which were performed in a single-institution setting during the period 2005 to 2012. From our review, we showed that the ratio of RALRP to RRP and LRP in the TCVGH had a trend toward RALRP during 2004−2009, and the incidence rate of prostate cancer in Taiwan was also increasing.[3] Therefore, we also analyzed the trend in operation numbers involving robotic surgery.

2. Methods

In December 2005, we established a urologic robotics team and adopted use of the conventional four-arm da Vinci robotic system. Thereafter, we performed a retrospective study about the application and use of robotic urologic surgery in a single institute. There were a total of 683 cases from December 2005 to December 2012. The database was IRB-approved and prospectively collected by investigators and the study coordinator. All surgeries were performed by nine operators, but one of the operators performed 582 cases. In our clinical series, radical prostatectomy was performed in 586 cases. There was pelvic lymph node dissection in 14 cases, dismembered pyeloplasty in nine cases, heminephrectomy in one case, partial nephrectomy in 27 cases, nephroureterectomy and radical cystectomy in six cases, nephroureterectomy and radical cystectoprostatectomy in three cases, nephroureterectomy with bladder cuff excision in 11 cases, partial cystectomy in two cases, ureteral reconstruction in one case, pyelolithotomy/ureterolithotomy in two cases, radical cystoprostatectomy or cystectomy with ileal conduit in five cases, nephropexy in two cases, simple prostatectomy in 12 cases, and adrenalectomy in two cases. We presented the perioperative outcome for each procedure, and also divided the 7-year course into three periods and analyzed the surgical capability of operations in 1 day over different periods by utilizing retrospective analysis.

3. Results

A total of 683 cases of robotic urologic surgeries were divided into three groups according to time intervals. The first group underwent operations from December 2005 to 2008 (a total 159 cases in 3 years). The second group had operations in 2009 to 2010 (a total 195 cases in 2 years) and the third group had operations in 2011 to 2012 (a total 329 cases in 2 years). We performed the first RALRP in December 2005, and then started utilizing such robotics with other types of procedures. In the first time interval, we performed radical prostatectomy, partial nephrectomy, and pyeloplasty. Then, we added nephroureterectomy with cystoprostatectomy and nephroureterectomy with bladder cuff excision in the second time interval. Then, we performed partial cystectomy, adrenalectomy, and nephropexy. Furthermore, various urologic surgeries were also performed, such as simple prostatectomy, radical cystoprostatectomy/cystectomy with ileal conduit reconstruction, ureteral reconstruction, and pyelolithotomy/ureterolithotomy (Table 1). There was an obvious increasing trend of radical prostatectomy and partial nephrectomy over these three studied periods.

We also analyzed the total operation time (skin to skin), blood loss and transfusion rate of the major operations and the procedures in larger numbers. The mean operation time of prostatectomy, partial nephrectomy, nephroureterectomy with radical cystectomy/cystectoprostatectomy, and nephroureterectomy was 154, 140, 295, and 129 minutes, respectively. The initial outcomes of different robotic procedures are represented in Table 2. Table 3 lists the reasons and results of all the conversion cases of radical prostatectomy and partial nephrectomy. As stated in our previous report, five of the 10 RALRP cases were due to a malfunction of the robotic system, and all of these occurred within the first 200 cases.[4] There was no surgical mortality or major complication that required surgical intervention within 30 days of all the applications.

We undertook our first urologic robotic surgery in December 2005.[3] As our experience with these procedures grew, we reduced the docking time, console time, and the total operation time; furthermore, we increased the complexity of robotic surgery. We were able to perform two robotic surgeries with a single standard da Vinci surgical system in 1 day for the first time in March 2007, three robotic surgeries a day in August 2009, four robotic surgeries a day in January 2012 and five surgeries a day in December 2012.

Table 1
Total case numbers and distribution in three time periods.

	Total numbers	Performed by single surgeon	2005−2008	2009−2010	2011−2012
	683	582	159	195	329
Radical prostatectomy	586	500	136	170	280
Partial nephrectomy	27	21	8	8	11
bil lymph node dissection	14	9	6	4	4
Dismembered pyeloplasty	9	7	3	1	5
Heminephrectomy	1	1	0	0	1
Nephroureterectomy and radical cystectomy	6	6	3	2	1
Nephroureterectomy and radical cystectoprostatectomy	3	3	0	3	0
Nephroureterectomy with bladder cuff excision	11	11	0	4	7
Partial cystectomy	2	1	0	0	2
Radical cystoprostatectomy or cystectomy with ileal conduit	5	4	0	0	5
Ureteral reconstruction	1	1	1	0	0
Pyelolithotomy/ ureterolithotomy	2	2	1	0	1
Nephropexy	2	2	0	0	2
Simple prostatectomy	12	12	1	3	8

Table 2
Perioperative outcomes of different robotic-assisted surgeries.

Procedure	Case number	Operation time, min (range)	Blood loss, mL (range)	Transfusion rate	Conversion rate (*n*)
Radical prostatectomy	586	154 ± 52	137 ± 165	2%	1.7% (10)
Partial nephrectomy	27	140 (72–210)	285.7 (20–2200)	11%	11.1% (3)
bil lymph node dissection	14	90 (70–120)	35 (20–200)	0	0
Dismembered pyeloplasty	9	138 (80–270)	<10	0	0
Nephroureterectomy and radical cystectomy/cystectoprostatectomy	9	295 (210–390)	470 (270–850)	33%	0
Nephroureterectomy with bladder cuff excision	11	129 (110–150)	63.3 (20–100)	0	0
Partial cystectomy	2	150 (145–155)	50 (50)	0	0
Radical cystoprostatectomy or cystectomy with ileal conduit	5	230 (230–320)	310 (100–700)	20%	0
Simple prostatectomy	12	150 (130–180)	208.3 (50–850)	8%	0

4. Discussion

In recent years, surgery that is less invasive has become a budding mainstay of the surgical domain. Laparoscopic surgery has been shown to have many advantages, such as shorter hospital stay, better cosmetic result, reduced postoperative pain, and a quicker return to normal physical activities. However, the learning curve of laparoscopic surgery is a significant issue for matters such as conversion of two-dimensional vision and the limited directional capacity of surgical instruments. Thus, there remains some difficulty in obtaining the necessary expertise, especially in complicated laparoscopic surgery, and longer operation time may be a consequence. However, investment in the robotic system brought about a new era of minimally invasive surgery. Although the cost-effectiveness of the robotic system has been an issue of frequent debate during the last decade, the benefit of a shorter learning curve as compared to laparoscopic surgery has already been statistically proven.[5] With high resolution, three-dimensional vision, and more delicate movement, the robotic system also contributes to an improved perioperative complication rate, oncologic outcome, potency rate, and urinary incontinence recovery in a series of systemic reviews of RALRP.[6–9] Robotic-assisted radical cystectomy (RARC) is also one of the blooming fields of urologic surgery. Richards et al[10] completed a critical review and showed that the learning curve does not compromise surgical outcome. Moreover, Ng et al[11] showed that RARC is more cost efficient than open cystectomy, especially with ileal-conduit, at a high-volume center. Recently, the advantages and disadvantages of robotic surgery as they related to prostate and bladder cancer have been reviewed.[12]

Table 3
Reasons and results of conversion cases of robotic-assisted laparoscopic radical prostatectomy (RALRP) and robotic-assisted partial nephrectomy (RAPN).

Case number	Reason	Result
RALRP		
3	da Vinci surgical system malfunction	Laparoscopy
1	Left external iliac vein injury	Convert to laparotomy
1	Software incompatibility before operation	Reschedule (delayed 6 hours)
2	Severe adhesion	Laparotomy
1	Urethral injury	Minimal laparotomy
1	Bleeding	Minimal laparotomy
1	da Vinci surgical system malfunction	3-arm system with laparoscopic assistance
RAPN		
2	Tumor margin involvement	Robotic-assisted radical nephrectomy
1	Renal vein injury	Laparotomy radical nephrectomy

Using RALRP, we conducted partial nephrectomy, and the initial results have convinced us that this technology experience could transfer to other complex surgeries.[13] Thus, it would appear that we expanded the application of robotic surgery. From 2005 to 2012, we effectively and successfully implemented use of the robotic system for a broader range of surgeries. Although there is manifestly the need to review such success with studies involving larger case numbers to demonstrate and validate the benefits of this system, all the procedures were performed safely and efficiently at our institute.

We expanded our indications for robotic surgery in an incremental manner, to ultimately substitute for all of the laparoscopic surgeries. Most importantly, there was a swelling volume of referral cases from other hospitals that further enriched our patient group and enabled us to perform different types of operations. In the future, we plan to include additional challenging cases for laparoscopic surgery, such as adrenal tumors > 7 cm, long segment ureteral stricture, cystectomy with total intracorporeal orthotopic bladder substitute, and reconstructive urologic surgeries.

We analyzed a total of 683 cases from 2005 to 2012. There were nine surgeons involved in the beginning, but one of them actually performed 582 of the operations. We noticed that patients tended to gravitate towards one experienced surgeon, and the surgical outcome also improved after the accumulation of experience. In 2005, after we finished the first RALRP, we could only perform one robotic surgery a day; by December 2012 we could perform five surgeries a day with the assistance of a single surgeon.

There are still a number of disadvantages associated with robotic systems, such as a long docking time and related expenses. However, the lighter arm of the da Vinci Si system helps to facilitate the docking of the robot. Further, docking time is no longer a major issue due to the valuable experience heretofore gained by our surgeons. Cost considerations are another major difficulty when attempting to expand the use of this system, especially in Taiwan, where the National Health Insurance program covers most medical expenses, but not those including robotic surgeries. As a result, costs can range from 5000 to 7000 USD depending on which procedure is involved.

In conclusion, application of the da Vinci robotic systems has been widely used in almost all clinical fields over the past decade. Based on our experience in a single institution, the robotic system can be applied safely and efficiently in the urologic area. We clearly observed satisfactory perioperative clinical courses and short-term surgical outcomes. In order to better understand long-term outcomes, however, a larger series with longer follow-up will be required.

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