Laparoscopy/Robotics

Experience With Robot-Assisted Laparoscopic Radical Prostatectomy at a Secondary Training Hospital: Operation Time, Treatment Outcomes, and Complications With the Accumulation of Experience

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Purpose: To investigate the learning curve and outcomes of robot-assisted laparoscopic radical prostatectomy (RALP) performed by a relatively lower volume surgeon at a secondary training hospital.

Materials and Methods: The medical records and the surgery video recordings of 100 patients who underwent RALP by a single surgeon between March 2010 and January 2013 were reviewed. The first 10 cases were grouped into period 1, cases 11 to 40 into period 2, cases 41 to 70 into period 3, and cases 71 to 100 into period 4. The interval between the operations, the operative time for each step of the surgery, the total console time, and the operative outcomes were investigated.

Results: The mean interval between surgeries was 10.6±9.3 days. The console time decreased progressively after the first 10 cases and reached under 3 hours after 75 cases. The time taken to begin dissection of the dorsal vein complex, for the division of the bladder neck, for lateral dissection with neurovascular bundle preservation, and for apex dissection decreased significantly with experience, although the time for vesicourethral anastomosis did not. The margin-positive rate of stage T2 patients was 27.4% (20/73), and the transfusion rate was 50% in period 1 patients and 3.3% in period 4 patients. No major complications occurred.

Conclusions: It is difficult to shorten the learning curve of surgeons in secondary training hospitals owing to the smaller number of cases and the irregular surgical intervals. Although the operation time was relatively longer, the surgical outcome and complication rates were comparable with those of surgeons at larger hospitals.

Keywords: Learning curve; Prostatectomy; Prostatic neoplasms; Robotics

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INTRODUCTION

The increasing availability of the prostate-specific antigen (PSA) screening test has led to earlier diagnosis of prostate cancer as well as to the promotion of more active treatment. Radical prostatectomy is one of the most common surgical methods for radical treatment of localized prostate cancer [1]. Laparoscopic radical prostatectomy (LRP) is a less invasive method of treatment that leads to less bleeding and rapid return to daily activities and also results in the same oncologic outcomes compared with open radical prostatectomy (ORP) [2]. However, the long learning curve and difficult surgical technique of LRP has hindered the generalization of its use. Compared with LRP, robot-assisted laparoscopic radical prostatectomy (RALP) enables a three-dimensional image with 10-fold magnification, wristed instrumentation, and prevention of biological tremor, leading to easier technique and a shorter learning curve. Therefore, RALP is now being used as an effective treatment option for radical prostatectomy [3]. Many studies in Korea have reported excellent oncologic and functional outcomes following early experiences with RALP [4,5].

However, those studies were conducted in large oncology centers where many surgical cases were performed in a short period of time, thus allowing for focused training. The learning curve and the surgical outcomes may differ between a secondary training hospital and a larger hospital owing to different surgical teams (including the assistant), different facilities, equipment, and the fact that the surgeon cannot perform multiple operations in a short period of time. Currently, a significant number of smaller oncology centers are also performing RALP, and with future improvements in surgical techniques and the reduction in costs, it is believed that RALP will become more widely used in secondary training hospitals. In the present study, we investigated the learning curve and the outcomes of RALP performed by a relatively lower volume surgeon at a secondary training hospital.

MATERIALS AND METHODS

The medical records of 100 patients who underwent RALP performed by a single surgeon between March 2010 and January 2013 were reviewed retrospectively to investigate the preoperative and postoperative clinical courses and the short-term surgical outcomes. The total duration over which the 100 RALP cases were performed was 33 months. All except one of the 100 patients were diagnosed by transrectal ultrasonography-guided needle biopsy and underwent abdomen and pelvis computed tomography or magnetic resonance imaging for staging.

Preoperative parameters including age, preoperative PSA, and prostate volume; intraoperative parameters such as the estimated blood loss (EBL), total console time, time of each step of the surgery, and intraoperative complications; and postoperative parameters including the transfusion rate, cardiopulmonary complications, and the oncologic and functional outcomes were compared and analyzed.

The first 10 cases of RALP were grouped into period 1, cases 11 to 40 into period 2, cases 41 to 70 into period 3, and cases 71 to 100 into period 4, and the interval between surgeries, the duration of each step of the surgery, the total console time, the transfusion volume, and the incidence of complications were investigated in each period. Considering that the surgeon lacked previous experience in LRP and had insufficient time to train to use the robot, the first 10 cases performed were categorized as "extremely early cases" and were thus put into period 1. The console time was defined as the time from the start of incision to the vesicourethral (VU) anastomosis based on the video recordings of the surgeries. Step 1 of the surgery was defined to be from the start of incision to the ligation of the dorsal vein complex, step 2 as the division of the bladder neck (BN) and dissection of the seminal vesicle (SV), step 3 as the lateral dissection including the neurovascular bundle preservation, step 4 as the dissection of the apex and urethra, and step 5 as the VU anastomosis. We analyzed the variation in the time for each step of the surgery.

All operations were performed by using the da Vinci surgical robot system (Intuitive Surgical, Sunnyvale, CA, USA) with 4 robotic arms, and a transperitoneal approach was used for all patients. The placement of one camera port and three ports for the robot instrument were installed as in previously reported studies [4]. All surgeries were performed by the same surgeon. The surgeon had experience in around 150 cases of open retropubic prostatectomy but did not have experience in LRP.

The dorsal vein complex was ligated for all cases, and lymph node dissection was performed in 37 cases. The time taken for lymph node dissection was not included in the operation time. For the first 70 cases, the anterior approach was used for the division of the BN and SV dissection, whereas for the remaining 30 cases, the posterior approach was used in which incisions were made at the posterior base followed by dissection of the SV and the vas deferens through the incisions before division of the BN. The decision to undergo neurovascular bundle preservation was made depending on the patient's preoperative International Index of Erectile Function (IIEF) and the oncologic status as evidenced by the patient's preoperative IIEF and magnetic resonance imaging results. In 72 of 84 cases, excluding 16 cases with preoperative serum PSA higher than 20 ng/mL, nerve sparing was performed by use of the interfascial technique (unilateral in 30 cases, bilateral preservation in 42 cases). After the prostate was resected, saline containing 200 mL of indigo Carmine was infused through the rectal tube to dilate the rectum and to inspect for rectal injury. Double-armed 3-0 Monocryl sutures were used for continuous suturing from a 6 o'clock to a 12 o'clock direction to complete the VU anastomosis.

1. Statistical analysis

The baseline characteristics and changes in the time of the operation steps were analyzed by using the Kruskal-Wallis test and chi-square test. A p-value smaller than 0.05 was considered to be statistically significant. All analyses were performed by using IBM SPSS ver. 18.0 (IBM Co., Armonk, NY, USA).

RESULTS

There were no significant differences in baseline characteristics among the patients in periods 1 to 4 (Table 1). The mean interval between each surgery was 10.6±9.3 days. The interval between the surgeries was 14.2±11.4, 12.1±11.3, 10.3±6.8, and 8.3±8.4 days for periods 1, 2, 3, and 4, respectively (p=0.272). The mean console time was 371 minutes for period 1 (Table 2), which was reduced steeply to 270 minutes for period 2, and then reduced slowly to 195 minutes for period 4. The console time first reached under 3 hours after 75 operations. Comparing the time of the surgical steps between periods 2, 3, and 4, when the basic operation of the robot was learned, the time taken for step 1 was reduced from 49±23.5 to 26.2±3.9 minutes (p=0.029). The time for step 2 decreased from 55.2±16.4 minutes in period 2 to 39.0±7.5 minutes in period 3, but there

TABLE 1. Preoperative, operative, and postoperative characteristics

Characteristic	Period 1	Period 2	Period 3	Period 4	Total
Mean age (y)	68.6±5.8	68.9±4.9	66.8±5.8	68.7±6.9	68.2±5.9
Mean preoperative PSA (ng/mL)	9.9±9.4	13.1±11.8	13.9±16.6	10.2±9.8	12.2±12.6
Prostate volume (mL)	30.9±14.5	39.6±17.0	32.8±12.7	31.3±10.9	34.2±14.1
Preoperative Gleason score	7.7±0.5	7.0±1.3	7.2±1.1	7.3±1.1	7.2±1.1
Postoperative Gleason score	7.7±0.9	6.7±2.0	7.3±1.02	7.3±0.7	7.2±1.4
Clinical stage ($\leq$T2/$\geq$T3)	8/2	19/11	3/7	23/7	73/27
Pathologic stage ($\leq$T2/$\geq$T3)	7/3	20/10	24/6	22/8	73/27
NVB preservation (none/unilateral/bilateral)	4/3/3	10/8/12	8/9/13	6/10/14	28/30/42

Values are presented as mean±standard deviation. Kruskal-Wallis test.
PSA, prostate-specific antigen; NVB, neurovascular bundle.

TABLE 2. Operation time in periods 1 to 4

	Period 1	Period 2	Period 3	Period 4	p-value	Total
Console time (min)	371.3±127.8	270.3±45.9	228.0±30.1	195.3±50.0	0.002	225.1±41.4
Start–DDVC ligation	51.8±2.9	49.0±23.5	35.8±3.9	26.2±3.9	0.029	41.4±15.3
BN & SV dissection	57.3±7.1	55.2±16.4	39.0±7.5	42.6±5.9	0.038	48.1±12.3
Lateral dissection	48.5±15.9	57.4±7.0	50.0±10.4	32.4±6.0	0.008	47.8±13.6
Apex	15.5±4.5	26.4±8.6	16.6±7.2	10.6±2.4	0.009	17.4±8.3
Anastomosis	49.5±11.7	55.0±12.1	45.6±4.7	40.0±3.3	0.095	47.9±9.7
Extra console time	110.8±35.7	23.6±9.2	36.2±11.5	27.8±16.8	0.001	49.6±41.4

Values are presented as mean±standard deviation. Extra console time refers to operation time excluding the time for steps 1 to 5 from the total console time. Kruskal-Wallis test.
DDVC, deep dorsal vein complex; BN, bladder neck; SV, seminal vesicle.

TABLE 3. Intraoperative and postoperative complications

	Period 1	Period 2	Period 3	Period 4	p-value
EBL (mL)	725±452.6	471±338.5	312.0±145.2	285.1±188.9	< 0.001
Transfusion	5/10 (50.0)	7/30 (23.7)	4/30 (13.3)	1/30 (3.3)	0.0005[a]
Transfused PRC, pint	1.40±1.58	0.37±0.72	0.45±1.21	0.2±1.10	0.03
Major complication	0	0	0	0	-

Values are presented as mean±standard deviation or number (%). Major complications include rectal injury, large bowel injury, etc. Kruskal-Wallis test.
EBL, estimated blood loss; PRC, packed red cell.
[a]:Chi-square test.

was no significant difference in the time for step 2 between periods 3 and 4 (p=0.038). The time taken for step 3 was 57.4±7.0 minutes in period 2 and 32.4±6.0 minutes in period 4 (p=0.008); and the time taken for step 5 was reduced significantly from 26.4±8.6 minutes in period 2 to 10.6±2.4 minutes in period 4 (p=0.009). However, the decrease in the time for step 5 was not significant (p=0.095). A posterior approach was used after the initial 70 cases and allowed easier dissection of the SV and more accurate BN division compared with the anterior approach, but the mean time was not significantly different from that for the anterior approach.

Of the 73 pathologic stage T2 patients, 20 showed a positive surgical margin (PSM). The margin-positive rate was 42.9% (3/7), 20% (4/20), 33.3% (8/24), and 22.7% (5/22) for periods 1, 2, 3, and 4, respectively, showing no statistical significance (p=0.308).

The mean intraoperative EBL decreased significantly from 725±452.6 mL in period 1 to 285.1±188.9 mL in period 4 (p < 0.001). Seventeen cases required transfusion (Clavien-Dindo classification grade II), which was reduced from 5/10 (50%) in period 1 to 1/30 (3.3%) in period 4 (Table 3). There were no major complications (Clavien-Dindo classification grade III or IV) during the surgery, such as large bowel or rectal injuries. A soft diet was started from day 2.1±1.5 postoperatively, and no cases of mechanical ileus developed.

Using the definition of urinary continence recovery of

TABLE 4. Postoperative recovery of continence

	Postoperative time (mo)			
	3	6	9	12
Period 1	3/9 (33.3)	5/9 (55.5)	8/9 (88.8)	8/9 (88.9)
Period 2	4/23 (17.4)	11/23 (47.8)	20/23 (86.9)	22/23 (95.7)
Period 3	12/28 (42.9)	18/28 (64.3)	24/28 (85.7)	25/28 (89.3)
Period 4	11/29 (37.9)	27/29 (93.1)	29/29 (100)	29/29 (100)
				p=0.049

Values are presented as number (%). Chi-square test.

needing to use one or fewer pads per day, of the 89 patients who could be followed up for more than 1 year after the operation or had recovery of continence at the last follow-up visit, 61 (68.5%) had recovered their continence, and only 4 (4.5%) were incontinent for 1 or more years. The rate of continence recovery at 3 months postoperatively in periods 1, 2, 3, and 4 was 3/9 (33.3%), 4/23 (17.4%), 12/28 (42.9%), and 11/29 (37.9%), respectively. The rate of recovery of continence at 6 months was 5/9 (55.5%), 11/23 (47.8%), 18/28 (64.3%), and 27/29 (93.1%), respectively. The number of patients who were incontinent after 1 year postoperatively was 1, 1, and 3 patients in periods 1, 2, and 3, respectively, whereas no patients from period 4 remained urinary incontinent for more than 1 year (p=0.049) (Table 4).

Among the patients who had erectile function (IIEF of 18 or more) preoperatively and underwent neurovascular bundle preservation, 6 of the 11 patients (54.4%) aged 65 years and under were able to masturbate or have sexual intercourse at 6 months postoperatively and 5 of the 11 patients (45.4%) aged 65 years and over were able to do so.

DISCUSSION

The results of the present study showed that the total console time decreased with the accumulation of surgical experience. The console time decreased to under 3 hours after the performance of 75 cases. In terms of the surgical steps, the time for all steps excluding the VU anastomosis decreased with experience.

Several studies have reported the intraoperative outcomes of RALP. For example, Park et al. [4] analyzed 200 cases of RALP performed in 24 months and reported that the total operation time, including the robot installation and the console time, was 215 minutes. Patel et al. [6] analyzed 200 cases of RARP performed over 18 months and reported the operation time to be 141 minutes. The console time excluding the robot installation time was 225 minutes in the present study, which was relatively longer than that reported in other studies. This is believed to be due to a longer learning curve in the present study, as there were 2.9 cases per month in our study, whereas the mean number of cases per month in the other studies ranged from 8.3 to 11.1.

It was reported that the operative time of RALP is not

significantly different from that of ORP and that RALP and ORP produce similar perioperative outcomes [7]. However, the studies from which these conclusions were drawn were comparisons in which the learning curve period was excluded. The operative time of RALP in the early stages of experience has been reported to vary between 247 and 540 minutes [8,9], although another study reported that with the accumulation of experience of the surgeon, the operative time decreased to be similar to that of ORP or even shorter [6]. The learning curve and the process of shortening and stabilizing the operation time and skill are necessary for all surgeons, and several studies have reported breakpoints at which there was a rapid decrease in the operation time. Sim et al. [9] reported that the robot installation time and the operation time decreased rapidly after the first 9 of the initial 17 cases of RALP. In another study, Lee et al. [10] analyzed 307 RALP cases performed over 36 months in 6-month units and showed that the mean operation time decreased rapidly for the first 6 months and then decreased gradually but without statistical significance. In the present study, the mean console time decreased rapidly after the first 10 cases, at the first breakpoint, and then reduced consistently afterwards. The console time decreased once more with statistical significance during cases 71 to 100 (second breakpoint).

As far as we know, this is the first study to investigate the learning curve for each step of the surgery. The time taken for steps 1 to 4 decreased significantly with the accumulation of surgical experience, but the time for step 5 decreased progressively but was not statistically significant. The extra console time, that is, the time for other activities excluding the 5 steps from the total console time, was longest for period 1 and was reduced significantly to reach a plateau after period 1. This is because for the first 10 cases, the surgeon had not overcome the learning curve and had insufficient understanding of the surgical plane and hesitated during the procedure. Furthermore, the surgical team, including the first assistant, had insufficient experience and cooperation. The significant reduction of the extra console time is thought to be due to the first breakpoint.

Step 1 is technically less difficult, and hence the time for this step is easily reduced with the accumulation of experience. For step 2, the accumulation of experience led to reduced violation of the surgical plane during the BN dissection. To reduce the time for step 2 even further, the surgeon performed the division of the BN and the SV dissection by a posterior approach from the 71st case onward. Although this clarified the anatomical borders and made the surgical process easier, it did not lead to a shortening of the operation time. The longest operation step in period 4 was the division of the BN and the SV dissection (step 2) and the VU anastomosis step (step 5). The time taken for step 2 decreased significantly, but the extent of the decrease in time of steps 2 and 5 was smaller than for the other steps.

The operations were successfully performed without major complications despite the fact that relatively smaller

numbers of operations were performed. However, the irregular interval between each operation and the lower number of operations still remain limiting factors for low-volume surgeons compared with large-volume surgeons in a tertiary medical center. We think that the only way for lower volume surgeons to overcome this limitation is to improve their techniques by use of laboratory practice, feedback from video self-review, and learning from video recordings of other surgeons and to work harder than larger volume surgeons.

Several studies have reported that EBL decreases significantly with surgical experience [6,10]. On the other hand, Jaffe et al. [11] reported that EBL was maintained without an association with surgical experience. In our study, EBL was 725 mL for the first 10 cases and was steadily reduced to 285 mL for the last 30 cases. The transfusion rate was also reduced to 3.3% for the last 30 cases. It is believed that the shortened operation time and the decreased surgical plane violation led to the decrease in bleeding.

The recovery of urinary continence after RALP is reported to be greater than 90% at 1 year after the operation, and the incidence of urinary continence recovery is relatively higher than with ORP [12].The incidence of continence recovery at 1 year postoperatively was 95.4% in the present study, and the urinary continence recovery rate at 3, 6, and 9 months after the operation increased with experience. We suspect that less unnecessary handling of the pelvic muscle during the procedure, less damage to the surrounding tissues, and a better process of securing sufficient urethral length during apex dissection may be reasons for this.

Although several studies have reported a lower PSM rate in RALP than in ORP, this has not been established with a high level of certainty [12]. There are limited reports about the learning curve of PSM. Jaffe et al. [11] reported that although 7 of the initial 12 cases (58%) had a PSM, this was reduced significantly to 10 of 89 (9%) in the later cases. A study done in Korea by Lee et al. [10] also reported that the PSM rate was reduced from 20.8% in the first year to 9.5% later. In the present study, the mean PSM rate in T2 stage patients was 27.4%, although a decrease in the PSM rate was not observed with the accumulation of surgical experience. We think that one of the causes of such results is the relatively small number of operations performed and the tendency of the surgeon to dissect close to the prostate during posterior dissection of the prostate owing to concerns of causing rectal injury. Further research and efforts to reduce the PSM rate may be needed in the future.

There were several limitations in the present study. First, it was not possible to analyze the effect of prostate volume and clinical stage on the variation in the operative time owing to the small sample size. This study was not a multicenter study; thus, its generalizability to the learning curve of all surgeons at secondary hospitals is limited. Also, the number of operations performed in the same period of time varied, which may have affected the acquiring of surgical techniques and hence the outcomes of the present study.

CONCLUSIONS

A smaller number of surgical cases with long and irregular intervals between surgeries could lead to a longer learning curve in secondary hospitals. Most surgical steps were significantly shortened with the accumulation of experience, but the time for VU anastomosis was not shortened significantly. Although the console time was relatively long, the intraoperative and perioperative complications and the functional outcomes were excellent.

CONFLICTS OF INTEREST
The authors have nothing to disclose.

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