Paradigm Shift from Open Surgery to Minimally Invasive Surgery in Three Approaches for Radical Prostatectomy: Comparing Outcomes and Learning Curves

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ABSTRACT

Objective: Radical prostatectomy (RP) can be performed by several approaches, such as open retropubic radical prostatectomy (RRP), laparoscopic radical prostatectomy (LRP), and robotic-assisted laparoscopic prostatectomy (RALP). This study investigated and shared the differences in the surgical techniques, learning curves, and outcomes of each approach of RP.

Materials and Methods: The data of patients who received RP given by one of the authors between January 2002 to June 2016 were retrospectively reviewed. We compared perioperative and postoperative outcomes among approaches, searched for predictors of a positive surgical margin (PSM), and assess the learning curves of the two minimally invasive approaches.

Results: 527 patients underwent RP during January 2002 to June 2016 including 42 RRP, 198 LRP, and 327 RALP. RALP had the highest negative surgical margin (68.8%) and lowest multifocal positive surgical margin (10.7%). PSM predictors were the Gleason score and pathological T staging. The learning curve showed that RALP needed one-hundred-cases experience to achieve the lowest PSM rate and 200 cases to master bleeding control. In the first 100 cases in each group, the PSM rate in LRP was lower than in RALP.

Conclusion: Minimally invasive approach in radical prostatectomy showed significant improvements over RRP, especially the RALP approach. RALP would take a surgeon 100 and 200 cases to reach the plateau on the learning curve for achieving the desired oncologic and perioperative outcome efficiencies, respectively. However, LRP and RRP are still feasible in a service setting and for training purposes.

Keywords: Radical prostatectomy; Laparoscopic; Robotic; Localized prostate cancer; Learning curve (Siriraj Med J 2022; 74: 618-626)

INTRODUCTION

Prostate cancer is one of the most commonly diagnosed cancers in male populations worldwide.[1] Back in the day, Thai patients usually developed lower urinary tract symptoms such as frequency, intermittent voiding, and a sense of residual urine as the tumor progressed extensively before their first visit to the hospital.[2] Therefore, initial radical prostatectomy (RP) had significant morbidity and mortality due to the late detection of cancer and poor understanding of the procedure. After early detection

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with PSA screening was adopted, it provided a window of opportunity to eradicate cancer while the patient was still in a curable state and encouraged surgeons to improve both their surgical technique and the operative outcome.[3]

Currently, RP is a standard treatment for localized prostate cancer. The procedure can proceed via several approaches: open retropubic radical prostatectomy (RRP), laparoscopic radical prostatectomy (LRP), and robotic-assisted laparoscopic prostatectomy (RALP).[3-9] Minimally invasive approaches (LRP and RALP) provide several benefits to both the patient and surgeon by helping minimize blood loss, shortening the hospital stay, and improving the oncological outcome in patients.[10,11] From the point of view of the surgeon, minimally invasive approaches allow a better-magnified vision, 3D perception, more comfortable ergonomic posture during operation, and intracorporal wrist rotation in RALP.[12,13]

The present study aimed to investigate and share the differences in the surgical technique, surgeon learning curve for RALP, and oncological outcome of each approach for RP.

MATERIALS AND METHODS

We retrospectively reviewed the RP cases from January 2002 to June 2016 performed by one of the authors (Sittiporn Srinualnad) since he was a novice in the field. In total, 567 cases were eligible for inclusion in the study, comprising 42 RRP cases, 198 LRP cases, and 327 RALP cases. The surgeon started to perform a high number of cases of RRP, LRP, and RALP in 2002, 2006, and 2007, respectively.

All patients were placed in low lithotomy with Trendelenburg position and were under general anesthesia. In RRP setting, the surgeon made a lower midline incision, while in LRP and RALP, the surgeon had laparoscopic ports set in position with one 12 mm camera port, three 8 mm working ports, a 12 mm assistant port, and a 5 mm assistant port. In RALP, the Intuitive da Vinci robotic surgical system (model S, Si, or Xi) was docked into position and its robotic arms were installed to all 8 mm working ports. For visualization, LRP was the only approach performed without depth perception as only 2D monitors were used. On the contrary, RALP had the consoles which provide 3D footage and RRP exposed the surgeon directly to the surgical field. After the initialization had been done, the retropubic radical prostatectomy was similarly commenced. Notably, in the dorsal venous complex (DVC) controlling step, the surgeon used barbed suture ligation to secure the vascular structures.

Preoperative, perioperative, and postoperative data consisting of the patient's demographics, stage of the disease, operative choice decision, operation details, pathological report of the excised gland, and follow-up information were reviewed and analyzed. The positive surgical margin (PSM), operative time, complication rate, perioperative blood loss, and blood transfusion rate were measured and compared among the groups.

The primary objective was defined to compare perioperative and postoperative outcomes of three different surgical approaches of radical prostatectomy. The secondary objectives were the identification of factors associated with PSM and the learning curves of two minimally invasive approaches.

Shapiro-Wilk test, D'Agostino K2 test, and Anderson-Darling test to evaluate the distribution of continuous data. Normally distributed data with mean and standard deviation were assessed using the Student's t-test. Non-normally distributed continuous data with the median and the interquartile range (IQR) were assessed using the Kruskal–Wallis test among groups. Categorical data are reported as the frequency and percentage and were assessed using the chi-square test. Each type of PSM, such as multifocal positive surgical margin (MPSM) and single focal positive surgical margin (SPSM), and the site of the PSM (i.e., apex, anterior, posterior, bladder neck) are reported as the frequency in each group and were assessed using the chi-square test. We also constructed univariate and multivariate analyses to find the predictors responsible for PSM.

Statistical analysis was performed using the Python statistical packages: SciPy version 1.5.2, lifelines version 0.25.10, and Matplotlib version 3.3.2. Univariate and multivariate analyses were performed using linear regression and multiple linear regression via the package statsmodels version 0.12.0. A p-value less than 0.05 was considered significant.

RESULTS

Demographics of the patients' group by surgical approach

Between January 2002 to June 2016, the author performed RP on 527 patients, of whom 42 (7.9%) were assigned to the RRP group, 198 (37.6%) to the LRP group, and 327 (62.0%) to the RALP group. The median ages of the patients in each group were 69.5 years old (IQR 63.3, 73.8), 68 years old (IQR 63.3, 73.0), and 66.4 years old (IQR 60.0, 73.0) for the RRP, LRP, and RALP groups. The median preoperative serum prostate-specific antigen levels (PSA) were 15 ng/ml (IQR 5.9, 33.6), 8.5 ng/ml (IQR 5.6, 18.8), and 8.9 ng/ml (IQR 5.9, 16.0), respectively, for the RRP, LRP, and RALP groups. The median prostate weights in each group were 46.0 g (32.0, 55.0), 38.8 g (31.0, 53.5), and 39.2 g (30.4, 49.6), respectively, for the RRP, LRP, and RALP groups. We found no significant differences in age, preoperative PSA, or prostate weight among the three groups of surgical approaches (Table 1).

Perioperative blood loss, as one of the evaluation indexes, was significantly different among the three groups with a p-value less than 0.01. The median blood loss in the RRP group was 1200 ml (900, 2000), which was the worst loss compared to its minimally invasive surgery (MIS) counterpart. Between the MIS approaches, LRP had a median blood loss of 800 ml (500, 1300) and RALP had a loss of 300 ml (200, 550) (Table 1).

The operative times were remarkably different with a p-value less than 0.01. The most time-consuming operation was LRP with a median duration of 265 minutes (215, 310). RALP had a median operative time of 180 minutes (155,220), while RRP still involved the lowest operative time of 165 minutes (145, 200) (Table 1).

Nerve-sparing attempts were significantly performed more frequently in RALP (26.6%) than RRP and LRP (7.1% and 9.6%, respectively) with a p-value < 0.01. We found that RRP had a significantly higher postoperative persistent PSA rate of 14.3% compared to the other approaches at 6.6% and 4.3% for LRP and RALP, respectively. Patients with seminal vesicle invasion proportionally underwent the RRP approach more frequently than any other approach with a p-value of 0.02, but this proportion between the two minimally invasive approaches was not significantly different (Table 2).

Adjuvant therapy was given proportionally the most frequently in the RRP group (42.9%) compared to LRP (17.2%) and RALP (28.8%), to cover any residual tumor at the PSM. Androgen deprivation therapy (ADT), which comprises bilateral orchidectomy or intramuscular injection of GnRH agonist, was the most popular selection, with 42.9%, 16.7%, and 27.8% of patients from the RRP, LRP, and RALP groups receiving ADT as either a single treatment or as a part of combination treatment as their adjuvant therapy. Novel androgen receptor inhibitors (AR) were rarely given after RRP (4.8%) and LRP (5.1%) but were given in 11.9% of patients after RALP. Radiation therapy was only given in combination treatment with ADT and/or AR, which happened in 0.5% and 7.7% of patients after LRP and RALP, respectively (Table 2).

TABLE 1. Characteristics of chronic low back pain patients.

	RRP (n = 42)		LRP (n = 198)		RALP (n = 327)		P-value
	Median	*IQR*	*Median*	*IQR*	*Median*	*IQR*	
Age (years old)	69.5	63.3 - 73.8	68	63.3 - 73.0	67	60.0 - 73.0	0.16
PSA (ng/mL)	15	5.9 - 33.6	8.5	5.6 - 18.8	8.9	5.9 - 16.0	0.21
post-op PSA (ng/mL)	0.01	0.00 - 0.06	0	0.00 - 0.03	0	0.00 - 0.01	0.08
Op-time (min)	165	145.0 - 200.0	265	215.0 - 310.0	180	155.0 - 220.0	< 0.01
Hospital stays after surgery (days)	8	7.0 - 10.0	8	7.0 - 9.0	7	7.0 - 8.0	< 0.01
Highest PSA after surgery (ng/mL)	0.1	0.00 - 0.90	0.1	0.01 - 0.56	0.03	0.00 - 0.40	0.39
Prostate (g)	46	32.0 - 55.0	38.8	31.0 - 53.5	39.2	30.4 - 49.6	0.33
F/u time (years)	6.8	1.3 - 12.2	6.9	2.6 - 9.3	5.49	2.3 - 8.2	0.01
Blood loss (ml)	1200	900.0 - 2000.0	800	500.0 - 1300.0	300	200.0 - 550.0	< 0.01
node gain	4.5	3.0 - 7.0	7	4.0 - 10.0	6	4.0 - 8.0	0.06
positive node	0	0.0 - 0.0	0	0.0 - 0.0	0	0.0 - 0.0	0.52

TABLE 2. Categorical data of patients categorized by the three surgical approaches.

	RRP (n = 42)		LRP (n = 198)		RALP (n = 327)		P-value
	n	%	n	%	n	%	
NVB sparing							
None	39	92.9%	179	90.4%	240	73.4%	<0.01
Unilateral	2	4.8%	4	2.0%	31	9.5%	
Bilateral	1	2.4%	15	7.6%	56	17.1%	
Pathological T stage							
0	0	0.0%	10	5.1%	4	1.2%	0.12
2	24	57.1%	103	52.0%	200	61.2%	
3a	5	11.9%	55	27.8%	76	23.2%	
3b	13	31.0%	30	15.2%	47	14.4%	
Pathological N stage							
pN0	39	92.9%	190	96.0%	315	96.3%	0.56
pN1	3	7.1%	8	4.0%	12	3.7%	
Seminal vesical invasion	13	31.0%	30	15.2%	46	14.1%	0.02
Extra prostatic extension	17	40.5%	81	40.9%	112	34.3%	0.28
Perineural invasion	25	59.5%	134	67.7%	243	74.3%	0.06
Persistent PSA	6	14.3%	13	6.6%	14	4.3%	0.03
Adjuvant therapy							
None	24	57.1%	164	82.8%	233	71.3%	<0.01
ADT	16	38.1%	23	11.6%	30	9.2%	
AR	0	0.0%	1	0.5%	2	0.6%	
ADT AR	2	4.8%	9	4.6%	37	11.3%	
ADT RT	0	0.0%	0	0.0%	7	2.1%	
AR RT	0	0.0%	0	0.0%	1	0.3%	
ADT AR RT	0	0.0%	1	0.5%	17	5.2%	
Immediate complication							
Surgical site infection	2	4.76%	0	0.0%	0	0.0%	0.22
Bowel injury	0	0.00%	1	0.5%	1	0.3%	
Ureter injury	0	0.00%	1	0.5%	0	0.0%	
Hematoma	0	0.00%	1	0.5%	1	0.3%	
Other	0	0.00%	0	0.0%	2	0.6%	
Delay complication							
inguinal hernia	5	11.9%	8	4.0%	27	8.3%	0.05
urethral stricture	3	7.1%	5	2.5%	4	1.2%	
incontinence	1	2.4%	5	2.5%	15	4.6%	
Gleason score from surgery							
6	9	21.4%	47	24.0%	86	27.5%	0.94
3+4	8	19.1%	68	34.7%	116	37.1%	
4+3	8	19.1%	34	17.4%	55	17.6%	
8	6	14.3%	22	11.2%	23	7.4%	
9	11	26.2%	24	12.2%	33	10.5%	
10	0	0.0%	1	0.5%	0	0.0%	

Abbreviations: ADT; Androgen deprivation therapy: including bilateral orchidectomy and GnRH-agonist injection, AR; Novel anti-androgen receptor therapy, RT; Radiation therapy.

Factors responsible for a positive surgical margin rate

According to Table 3, only the negative surgical margin rate (NSM) and MPSM rate were significantly different among the surgical approaches, with a p-value less than 0.05. RALP had the highest NSM rate (68.8%) and the lowest MSPM rate (10.7%), while RRP remained on the worst side with a 50.0% NSM and 28.6% MPSM.

Having categorized SPSM into specific sites where the PSM resides, we found that the statistical analysis did not find a significant difference for the PSM sites among the three approaches, and the most common site of SPSM was at the apex of the prostate for all approaches (11.9% in RRP, 20.2% in LRP, 20.2% in RALP).

While the frequency of patients with each pathological T staging (pT) was not significantly different among the three approaches (Table 2), the PSM rates were. We detected significantly higher odds ratios of PSM in the pT3a and pT3b stages compared to the pT2 stage in both the univariate and multivariate models, with a p-value less than 0.001 (Table 4).

The nerve-sparing technique was attempted significantly more frequently in RALP than in the other surgical approaches, with a p-value less than 0.01 (Table 2). The data on the univariate analysis showed that the bilateral nerve-sparing technique might lower the PSM rate, with an odd ratio of 0.40, 95% confidence interval -1.53 to -0.30, and p-value of less than 0.01, but the multivariate analysis proved otherwise (Table 4).

Learning curve

The split method was used to analyze the learning curves of the surgeon for all approaches of RP, as presented in Table 5. The 567 patients in total were split into two groups chronologically. Perioperative blood loss, transfusion rate, and NSM all improved over time. Delay complications were the only group that did not seem to be related to the surgeon experience. According to Table 2, the most common delay complication encountered was an inguinal hernia, which is common in 50–69-year-old men.[14]

Furthermore, subgroup learning curve analysis was performed, especially for the minimally invasive surgery platform, as shown in Fig 1. The factors focused on were perioperative blood loss, number of cases that received blood transfusion, surgical margin status, hospital stay after surgery, and number of dissected lymph nodes.

In Fig 1, it can be seen that both the perioperative blood loss and transfusion rates showed a relative decrease with the increasing experience of the surgeon in the RALP approach, whereas the LRP approach group still had relatively high perioperative blood loss and needed transfusions more often than for RALP. By the time the surgeon's RALP experience had reached the 90th case, the transfusion rate was almost reduced in half. LRP still needed experience from over 100 cases to show a reduced transfusion rate.

For the positive surgical margin, the RALP learning curve suggested it would take around 90-120 cases to achieve a plateau, which was faster than for LRP. However, LRP was able to achieve a lower PSM rate than RALP in the first 100 cases (Fig 1).

In terms of the operative time, the learning curve had already taken place at 30–60 cases of RALP and continued to reduce to a plateau at the 200th case. LRP also could reduce the operative time within the first 100 cases, but it could not match RALP's slope, as shown in Fig 1.

TABLE 3. Frequency of PSM among the three surgical approaches.

	RRP (n = 42)		LRP (n = 198)		RALP (n = 327)		P-value
	n	%	n	%	n	%	
Negative SM	21	50.0%	127	64.1%	225	68.8%	0.04
SPSM	10	23.8%	67	33.8%	129	39.5%	0.09
Apical	5	11.9%	40	20.2%	66	20.2%	0.43
Posterior	3	7.1%	10	5.1%	31	9.5%	0.18
Posterolateral	0	0.0%	1	0.5%	2	0.6%	0.87
Anterior	0	0.0%	1	0.5%	7	2.1%	0.22
Bladder neck	1	2.4%	15	7.6%	23	7.0%	0.47
Vas Deferens + Seminal Vesicle	1	2.4%	0	0.0%	0	0.0%	
MPSM	12	28.6%	29	14.7%	35	10.7%	< 0.01

TABLE 4. Univariate and multivariate analyses of the risk factors for PSM.

	Univariate analysis Crude OR (95% CI)	P-value	Multivariate analysis Adjusted OR (95% CI)	P-value
Surgical approach				
RRP	1(ref)		1(ref)	
LRP	0.6(-1.3, 0.1)	0.089	0.7(-1.1, 0.5)	0.399
RALP	0.5(-1.4, -0.1)	0.017	0.7(-1.2, 0.4)	0.343
Gleason score				
6	1(ref)		1(ref)	
3+4	3.8(0.7, 1.9)	<0.001	2.3(0.2, 1.5)	0.012
4+3	3.9(0.7, 2.0)	<0.001	2.2(0.04, 1.5)	0.037
8	11.3(1.7, 3.2)	<0.001	5.9(0.9, 2.6)	<0.001
9	20.3(2.3, 3.8)	<0.001	6.9(1.1, 2.8)	<0.001
NVB sparing				
None	1(ref)		1(ref)	
Unilateral	0.5(-1.6, 0.03)	0.058	0.5(-1.6, 0.4)	0.211
Bilateral	0.4(-1.5, -0.3)	0.004	0.6(-1.2, 0.2)	0.148
Pathological T				
pT2	1(ref)		1(ref)	
pT3a	4.4(1.1, 1.9)	<0.001	3.1(0.6, 1.6)	<0.001
pT3b	8.8(1.7, 2.7)	<0.001	3.6(0.6, 1.9)	<0.001
PSA (ng/ml)				
<10	1(ref)		1(ref)	
10 to 20	1.3(-0.2, 0.7)	0.280	0.9(-0.6, 0.5)	0.791
>=20	3.8(0.9, 1.8)	<0.001	1.3(-0.3, 0.8)	0.356
Prostate volume (g)				
<25	1(ref)			
25 to 50	0.9(-0.8, 0.5)	0.638		
50 to 75	0.6(-1.3, 0.2)	0.150		
>=75	0.8(-1.1, 0.6)	0.602		

TABLE 5. Split method analysis of the learning curves

Outcome	First half (n = 284)		Later half (n = 283)		P-value
NSM (n, %)	157	55.5%	216	76.1%	<0.05
SPSM (n, %)	109	38.5%	97	34.2%	0.31
MSPM (n, %)	43	15.2%	33	11.6%	0.22
Immediate complication (n, %)	5	1.8%	4	1.4%	0.74
Delay complication (n, %)	25	8.8%	49	17.3%	<0.05
Blood transfusion (n, %)	104	36.8%	25	8.8%	<0.05
Blood loss (median, IQR)	700	400-1200	350	200-600	<0.05

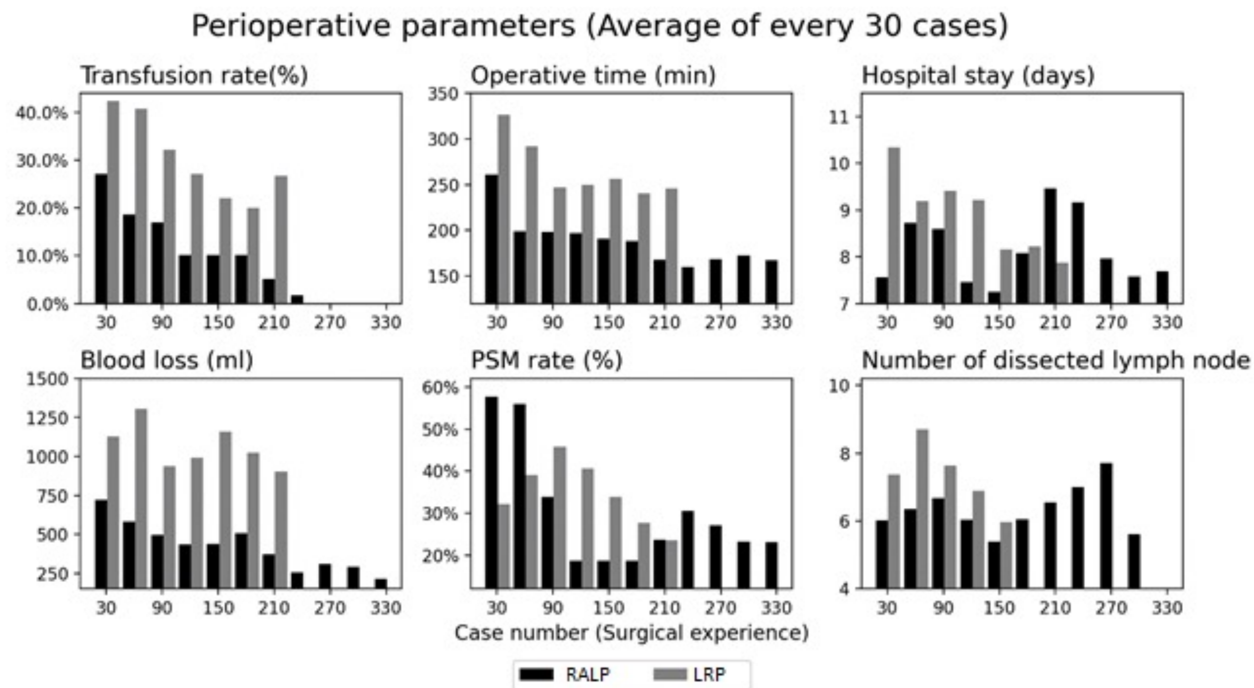

Fig 1. Learning curve analyses using perioperative parameters and a subgrouping of every 30 cases

DISCUSSION

Originally when RP was first developed, patients were usually diagnosed as having prostate cancer with a higher clinical and pathological stage due to the lack of screening serum PSA level. The outcome of the procedure was described as very poor and played very little part in the management. After the serum PSA level was widely used as a screening tool, patients could have prostate cancer diagnosed 7–9 years earlier than previously was possible, which meant it was more likely to be found in a curable stage of the disease. Later, Patrick Walsh made dramatic contributions to the RP field by sharing a better understanding of the anatomy of the prostate, which he described by a cavernous nerve-sparing technique, and he proposed DVC ligation for early bleeding control.[3,15] The procedure then achieved improvements in both safety and functional outcome. After that, the laparoscopic approach came into play for pelvic lymph node dissection early on. Then, LRP was first described in 2000.[3,16]. The procedure could clearly improve patient recovery but still could not achieve a comparable functional outcome, i.e., continence. In the 21st century, RALP was introduced to the field. The procedure drove another revolution in outcome expectations by reducing the transfusion rate to near zero while requiring only 24 hours hospital stay, and achieving better functional outcomes in terms of both continence and sexual function.[3]

Although the average blood loss of RALP is similar to the previous publication with a mean of 300 and IQR of 200-500 mL, LRP is more complicated.[10] For LRP, the step that is majorly responsible for bleeding is controlling DVC, which could be done in two manners: suture ligation or endoscopic stapler. In this study, the surgeon favors the suture ligation technique with barbed suture material over another technique. Even though the two techniques shouldn't make difference in estimate blood loss[17], two potential reasons might entitle for more blood loss in LRP group. Firstly, as the surgeon aimed for preserving urethral length to secure long-term functional outcomes of the patients, he made fewer ligations on DVC. With the cruder movement of LRP, sometimes the suture was slipped and led to more bleeding. The second explanation associate with tumor location as apical tumor did increase the difficulty of the dissection step and needed wider excision around DVC, which directly related to more bleeding.

Regarding Saksirisampant et al, although PSM status could be influenced by several preoperative factors, which were serum PSA level, small prostate, percentage of tumor volume, pathological T stage, and ISUP Gleason grade group, it is one of the outcomes that directly demonstrate one's surgical skills.[18] The surgeon's always responsible for the decision making whether to perform wider excision on which border to compensate for the aggressiveness of the tumor. Having prostate MRI preoperatively might help specify tumor's locations and boundaries, which aware the surgeon of those areas and eventually reduce PSM.

While the oncological outcome result showed little to no difference among the three approaches of RP[10,11], outcomes in the perioperative and immediate postoperative periods, such as blood loss, transfusion rate, and postoperative hospital stay, were improved significantly in RALP. Recent research in the field suggests that a single night's stay or same-day discharge might be possible for selected patients regarding safety.[19,20] Compared to our study, RALP did show a lower transfusion rate and minimized the immediate complications, while our data did not show an extremely shortened hospital stay due to various reasons, such as institute policy and the patients' request. Implementing enhanced recovery after surgery (ERAS) protocols might be one solution that could contribute toward this outcome.[21-23]

Between the two minimally invasive approaches, there are many differences in the way the operations are performed. LRP uses surgical instruments that need holding and control directly by the surgeon's hand in the surgical field themselves, whereas RALP has a surgical robot to hold and move the instruments, which the surgeon operates from a console in a sitting posture. The time required to initialize for each operation is obviously longer in RALP, including the cleaning and docking time, but the RALP console time could be reduced lower than in LRP with a more experienced surgeon. While RALP may lack haptic feedback from the operating field, the platform allows the surgeon to operate with steady tool movement, at ease and in a relaxed manner. Therefore, RALP helps reduce fatigue and minimize the surgeon's stress. With a good magnifying view and precise movement, robotic-assisted surgery eliminates the need for excellent human eye vision and perfectly steady human hand movement. Therefore, it could extend the surgeon's retirement age in terms of overcoming the physical limitations due to their increasing age.

According to our study, RALP would take around 100 cases to master full PSM control and another 100 cases to achieve minimal blood loss and operative time, which was similar to in Song et al. and Kongchareonsombat's studies that marked 230 operations experience as needed for the best bleeding control performance in RALP.[24,25] Compared to LRP in the same evaluating matrix, LRP would take a much longer time to improve the outcome and would achieve even less. According to Secin et al., it would take 200 to 250 cases to find the plateau for the PSM rate in the learning curve of LRP.[26] Due to the limitations of our dataset, which consisted of only 198 cases of LRP, our findings on this issue remain inconclusive in our study.

Interestingly, the oncological outcome (i.e., PSM) was poorer in RALP at the beginning of the surgeon's expertise. However, after 100 cases of experience were gained, the surgeon's performance in RALP eventually surpassed LRP with a very surprising steep slope for the PSM rate. The surgeon's familiarity with the platform may play an important role in this finding, because the loss of tactile sensation, hand-eye coordination process, and tools handling may not play along with the surgeon's expectations in the early phase of their learning experience. However, after the surgeon has become more familiar with the robotic platform and can handle it well, then the PSM rate is improved.

With the advancement of technology and surgical options, there might be some questions regarding whether RRP should be performed in the modern-day. Despite the improvement in outcomes that RALP may give, we believe that there is still some role for RRP to play. For example, barriers to financial affordability and accessibility to a minimally invasive surgery platform should allow RRP to continue thriving in this century. In some countries where surgical fees may also increase by the time under anesthesia, a shorter operative time might have a considerable beneficial impact for patients with financial problems. Therefore, many surgeons still see benefits in the RRP approach and will continue to refine their skills in this area. Recently, they can even match some of RRP's beneficial outcomes to the MIS platform, such as sexual function and continence function.[27-29]

There are limitations in learning curve interpretation including a possible confounder as the author started performing these three approaches of RP at different times in his career. We believe some surgical experience could be used as cross-platform knowledge, whereby the outcome of learning a later proposed surgical approach, such as RALP, could be confounded by prior experience of RRP and LRP.[30] Therefore, the number of cases required for a surgeon who is a complete novice in minimally invasive surgery to learn RALP could not be determined by this study and needs further research.

CONCLUSION

Nowadays, urologists in academic centers have a high interest in the MIS approach of RP and prefer RALP most of the time. RALP has clear advantages in disease control and hospital resource utilization. Here, learning curve analysis determined that 100 cases of RALP were the minimal requirement for a surgeon to master the procedure. However, not all patients can afford such an operation and cost is a major concern. Therefore, LRP and RRP still play important roles in both service hospital settings and academic training centers.

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