Original Article

Perioperative Outcomes and the Learning Curve for Robotic-Assisted Laparoscopic Radical Prostatectomy in Thailand by a Single Surgeon: Six Years' Experience in Ramathibodi Hospital

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Objective: To report the peri-operative outcomes and positive surgical margin (PSM) and to analyze the surgical learning curve of one of the longest single-surgeon experiences in Thailand.

Materials and Methods: Between January 2013 and July 2018, 330 robotic-assisted laparoscopic radical prostatectomies (RALRPs) were performed. Patients' data were collected retrospectively to evaluate peri-operative and pathological outcomes. These data included age, body mass index (BMI), serum prostate-specific antigen (PSA) levels, operative time, estimated blood loss (EBL), surgical laceration rate, length of hospital stay, clinical and pathological stage, Gleason score (GS) on biopsy specimen, specimen weight (g), and marginal status.

Results: Of the 330 RALRPs performed, the median total operation time, median EBL, surgical laceration, length of hospital stay, and total PSM were 190 (165 to 230) minutes, 300 (200 to 500) ml, 0.6% (2), 5 (4 to 8) days, and 38%, respectively. The present surgeon's learning curve indicated that operative times, EBL, and PSM in pathologically organ-confined disease (pT2) were strongly correlated with the cumulative experience from the initial 50 cases (p<0.001 and 0.017, respectively) and the initial 100 cases (p=0.007), respectively. However, surgical laceration and length of hospital stay were not correlated with the surgeon's cumulative experience (p=0.596 and 0.073, respectively).

Conclusion: The peri-operative outcomes and PSM for RALRP are promising. The initial learning curve was about 100 cases for a surgeon to adequately master the required skills.

Keywords: Learning curve, Prostate cancer, Radical prostatectomy, Robot-assisted laparoscopic surgery, Perioperative outcome

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Prostate cancer is the fifth most common cancer among Thai men(1). It is now at 6.36%, having risen from sixth most common (at 5.15%) within the past year(2). Furthermore, the number of cases continues to increase. Radical prostatectomy (RP) is a standard measure in the treatment of clinically localized prostate cancer and a possible alternative for the treatment of locally advanced disease. RP can be performed using open radical prostatectomy (ORP), laparoscopic radical prostatectomy (LRP), or robotic-assisted laparoscopic radical prostatectomy (RALRP) techniques. Aside from its known advantages as a minimally invasive procedure, RALRP has emerged as a promising technique, offering superior visualization of the surgical process and the patient's anatomy(3), facilitating a more comfortable procedure for the surgeon and improving peri-operative outcomes, such as operative time, estimated blood loss (EBL), transfusion rate, surgical laceration rate(4,5), oncological outcomes(4,6), and functional outcomes(7-9). Moreover, instruments and techniques undergo continuous development, including the development of the da Vinci Surgical System's Si (TME-Si) and Xi (TME-Xi) models(10-12).

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Procedural outcome generally depends on the surgeon's experience. Therefore, the learning curve concept is frequently brought to bear on a variety of surgical techniques[13-15]. Unfortunately, very few Thai centers have reported the learning curve and outcomes of RALRP. The objective of the present study was to report a single surgeon's experience of RALRP with reference to the learning curve, peri-operative outcomes, and positive surgical margin (PSM).

Methods and Materials

Population

Between January 2013 and July 2018, 330 prostate cancer patients underwent RALRP procedures performed by the same surgeon, who had considerable expertise on RP (having performed approximately 500 cases), with experience in ORP, LRP, and RALRP at Ramathibodi Hospital in Thailand.

Surgical technique

RALRP was performed using the da Vinci Surgical System Si. A transperitoneal approach was used, using five trocar ports of the conventional four-armed da Vinci Surgical System (TME-Si) and one arm for assistance. A drain was routinely placed and removed when the amount dropped to below 50 ml/day. The urethral catheter was removed after a cystogram was performed and judged to be normal at post-operative day 14.

Baseline characteristics, operative, and post-operative parameter

The following data were collected from all patients, age, body weight (kg), height (cm), body mass index (BMI), prostate-specific antigen (PSA) level, underlying disease, clinical stage (TNM classification), and Gleason score (GS) of the biopsy specimen.

All specimens were evaluated by an experienced uropathologist in accordance with the National Comprehensive Cancer Network (NCCN) guidelines, and reported as prostatic weight (g), pathological stage, and GS of specimen.

Peri-operative outcomes

Peri-operative outcomes included operative time (minutes), EBL (mL), surgical laceration of the bladder, rectum, ureter, bowel and blood vessel, and length of hospital stay (days), which was calculated by subtracting the date of admission from the date of discharge.

Positive surgical margin

PSM was defined as cancer cells extending to the inked surface of the specimen[16].

Statistical analysis

A descriptive study was performed. The data were analyzed using the Kruskal-Wallis test, the chi-squared test and the unpaired t-test to identify the statistical significance of the differences in means ± standard deviation, median (interquartile range), and proportions, respectively. Analysis was accomplished using Stata version 14, with a p-value less than 0.05 was considered statistically significant.

Results

Patient demographics and operative and post-operative parameters are presented in Table 1. There was no statistically significant association between the surgeon's experience and other parameters (i.e., age, weight, height, BMI, pre-operative PSA level, pre-operative biopsy Gleason score, pre-operative clinical T stage, post-operative specimen Gleason score, and pathological T stage). The prostate volume, however, exhibited significantly different results (p=0.041).

The peri-operative outcomes, including operative time, EBL, surgical laceration, and length of hospital stay, in each of the 50 cases, are shown in Table 2. Median total operative time, median EBL, surgical laceration, and hospital stay were 190 (165 to 230) minutes, 300 (200 to 500) ml, 0.6% (2) and 5 (4 to 8) days, respectively. Operative times and EBL were strongly correlated with the surgeon's cumulative experience from the initial 50 cases, as graphically depicted in Figure 1 and 2 (p<0.001 and 0.017, respectively). However, surgical laceration and length of hospital stay were not correlated with the surgeon's cumulative experience (p=0.596 and 0.073, respectively).

Overall, the PSM was 38% (125 of 330 cases). The PSM was 21.9% (40) in pT2 and 59% (85) in pT3. Although the overall PSM and the PSM in pathologic extracapsular extension were not correlated with the surgeon's cumulative experience (p=0.063 and 0.139, respectively), the PSM was correlated with the surgeon's cumulative experience from the initial 100 cases of pathologically organ-confined disease (pT2) (p=0.007), as shown in Table 3 and Figure 3.

Discussion

RALRP was introduced at Ramathibodi Hospital, Thailand, in 2013, and displaced ORP and LRP as a result of its many advantages. RALRP provides a clear,

Table 1. Demographic data

Demographic data	Group 1 (n=50) n (%)	Group 2 (n=50) n (%)	Group 3 (n=50) n (%)	Group 4 (n=50) n (%)	Group 5 (n=50) n (%)	Group 6 (n=50) n (%)	Group 7 (n=30) n (%)	Total (n=330) n (%)	p-value
No. of patients	50 (15.2)	50 (15.2)	50 (15.2)	50 (15.2)	50 (15.2)	50 (15.2)	30 (9.1)	330 (100)	-
Age (year), Median (IQR)	67 (62 to 71)	66.5 (61 to 72)	67 (62 to 70)	66 (62 to 71)	68 (63 to 71)	69 (63 to 73)	66.5 (64 to 70)	67 (63 to 71)	0.7715[a]
Body weight (kg), Median (IQR)	66.9 (62.5 to 72.2)	68.4 (60 to 73)	69.0 (62.2 to 75.8)	65.3 (56 to 74)	67.5 (61.6 to 72.6)	65.7 (62 to 76)	66.7 (63 to 73.1)	67.1 (61.8 to 73.8)	0.622[a]
Height (cm), Median (IQR)	165 (161 to 168)	167 (161 to 170)	165 (162 to 169.2)	165 (160 to 169)	166 (163 to 170)	167 (162 to 170)	165 (160 to 169)	165 (161.6 to 170)	0.611[a]
BMI (kg/m^2), Median (IQR)	24.2 (22.4 to 26.4)	24.25 (22.4 to 27.3)	25.2 (22.5 to 28.1)	23.85 (21.6 to 25.8)	24.4 (22.5 to 26.6)	24.4 (22.5 to 26.2)	24.2 (23.6 to 27.7)	24.3 (22.5 to 26.7)	0.416[a]
PSA pre-op/PSA level (ng/ml), Median (IQR)	11.21 (7.1 to 14.8)	11.53 (7.7 to 27)	10.47 (7.1 to 24.0)	11.84 (9.4 to 31.2)	13.57 (8.8 to 19.8)	13.20 (7.9 to 19.3)	11 (8.1 to 14.8)	11.6 (7.9 to 20)	0.344[a]
Clinical stage									0.084
T1a	0 (0.0)	1 (2.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.3)	
T1b	1 (2.0)	0 (0.0)	1 (2.0)	0 (0.0)	1 (2.0)	0 (0.0)	0 (0.0)	3 (0.9)	
T1c	43 (87.8)	37 (74.0)	36 (72.0)	38 (76.0)	45 (90.0)	46 (92.0)	29 (96.7)	274 (83.3)	
T2a	-	-	-	-	-	-	-	-	
T3a	0 (0.0)	3 (6.0)	3 (6.0)	5 (10.0)	3 (6.0)	2 (4.0)	1 (3.3)	17 (5.2)	
T3b	5 (10.2)	9 (18.0)	10 (20.0)	7 (14.0)	1 (2.0)	2 (4.0)	0 (0.0)	34 (10.3)	
T3c	-	-	-	-	-	-	-	-	
T4	-	-	-	-	-	-	-	-	
Biopsy GS, Median (IQR)	7 (6 to 7)	7 (6 to 7)	7 (7 to 7)	7 (6 to 8)	7 (6 to 7.5)	7 (6 to 8)	7 (6 to 8)	7 (6 to 8)	0.206[a]
Pathological stage									0.351
T2a	7 (14.6)	5 (10.0)	3 (6.0)	1 (2.0)	0 (0.0)	3 (6.0)	4 (13.3)	23 (7.0)	
T2b	1 (2.1)	1 (2.0)	0 (0.0)	0 (0.0)	1 (2.0)	1 (2.0)	0 (0.0)	4 (1.2)	
T2c	23 (47.9)	27 (54.0)	21 (42.0)	18 (36.7)	25 (50.0)	26 (52.0)	16 (53.3)	156 (47.7)	
T3a	7 (14.6)	7 (14.0)	15 (30.0)	16 (32.7)	14 (28.0)	11 (22.0)	6 (20.0)	76 (23.2)	
T3b	10 (20.8)	10 (20.0)	11 (22.0)	14 (28.6)	10 (20.0)	9 (18.0)	4 (13.3)	68 (20.8)	
T4	-	-	-	-	-	-	-	-	
Pathologic GS, Median (IQR)	7 (7 to 7)	7 (7 to 7)	7 (7 to 8)	7 (7 to 8)	7 (7 to 8)	7 (7 to 8)	7 (7 to 8)	7 (7 to 8)	0.214[a]
Prostate volume (g), Median (IQR)	33.5 (25.0 to 44.5)	35 (28.4 to 44.2)	39.35 (30.8 to 48.2)	37.4 (27.9 to 45.4)	34.2 (30.0 to 45.0)	39.2 (31.3 to 55.9)	43.9 (35.4 to 56.8)	37.4 (29.8 to 47.5)	0.041[a]*

BMI=body mass index; PSA=prostate-specific antigen; GS=Gleason score; IQR=interquartile range

* p<0.05 indicates statistical significance, [a] Comparison of groups by the Kruskal-Wallis test

Table 2. Perioperative outcomes

Perioperative outcomes	Group 1 (n=50) Median (IQR)	Group 2 (n=50) Median (IQR)	Group 3 (n=50) Median (IQR)	Group 4 (n=50) Median (IQR)	Group 5 (n=50) Median (IQR)	Group 6 (n=50) Median (IQR)	Group 7 (n=30) Median (IQR)	Total (n=330) Median (IQR)	p-value
Operative time (minute)	250 (195 to 295)	217.5 (180 to 245)	202.5 (175 to 240)	180 (160 to 215)	180 (165 to 200)	180 (140 to 210)	145 (120 to 165)	190 (165 to 230)	0.0001[a]*
EBL (mL)	400 (300 to 500)	300 (200 to 500)	325 (250 to 500)	300 (200 to 400)	300 (200 to 400)	300 (200 to 400)	300 (200 to 500)	300 (200 to 500)	0.017[a]*
Surgical laceration, n (%)	0 (0.0)	0 (0.0)	1 (2.0)	0 (0.0)	1 (2.0)	0 (0.0)	0 (0.0)	2 (0.6)	0.596
Hospitalization time (day)	5.5 (5 to 8)	6 (5 to 9)	6 (5 to 8)	6 (4 to 8)	5 (4 to 6)	5 (4 to 7)	5 (4 to 6)	5 (4 to 8)	0.073[a]

EBL=estimated blood loss; IQR=interquartile range

* p<0.05 indicates statistical significance, a Comparison of groups by the Kruskal-Wallis test

Table 3. Marginal status

Margin (positive)	Group 1 (n=50) n (%)	Group 2 (n=50) n (%)	Group 3 (n=50) n (%)	Group 4 (n=50) n (%)	Group 5 (n=50) n (%)	Group 6 (n=50) n (%)	Group 7 (n=30) n (%)	Total (n=330) n (%)	p-value
Overall	26 (53.1)	18 (36.0)	18 (36.0)	14 (28.0)	24 (48.0)	18 (36.0)	7 (23.3)	125 (38.0)	0.063
pT2	14 (45.2)	10 (30.3)	3 (12.5)	1 (5.3)	5 (19.2)	5 (16.7)	2 (10.0)	40 (21.9)	0.007*
pT3	12 (70.6)	8 (47.1)	15 (57.7)	13 (43.3)	19 (79.2)	13 (65.0)	5 (50.0)	85 (59.0)	0.139
pT4	-	-	-	-	-	-	-	-	-

* p<0.05 indicates statistical significance

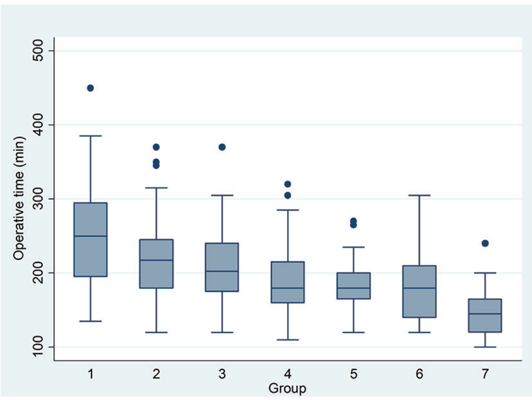

Figure 1. Operative time (minute) by each 50 patients.

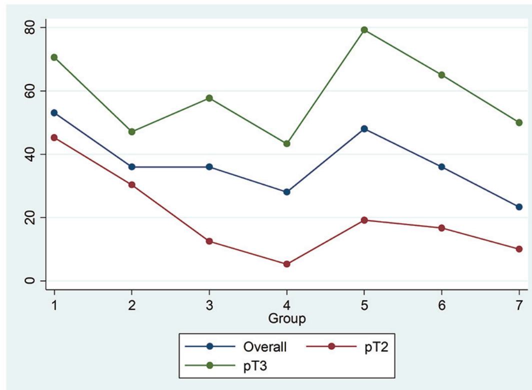

Figure 3. Percent of positive margin by each 50 patients.

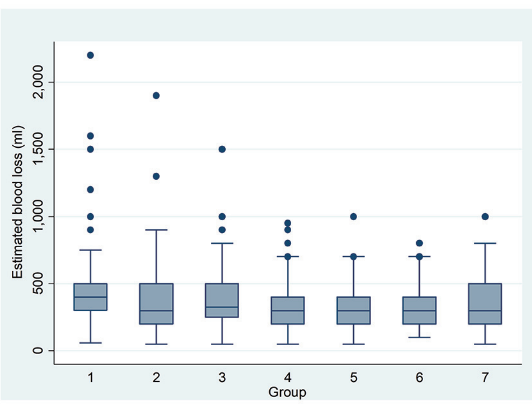

Figure 2. Estimated blood loss (ml) by each 50 patients.

three-dimensional (3D) view of the operative field and facilitates suturing and dissection by substituting large-scale hand movement with tiny instrument movement, which reduces vibration and frees the grasp to allow for shaft rotation movement at the tip (EndoWrist, Intuitive Surgical). The present study reported one of the longest single-surgeon experiences of using RALRP in Thailand, with peri-operative outcome and PSM data.

In the present study, median total operative time and EBL were 190 (165 to 230) minutes and 300 (200 to 500) ml, respectively, which significantly differed after the first 50 cases [(250 (195 to 295) versus 217.5 (180 to 245) minutes, p<0.001] and [400 (300 to 500) versus 300 (200 to 500) ml, p=0.017], confirming the findings of previous studies(17,18). These can be attributed to the superior visualization of the anatomy offered by the 3D view and magnification, the ability to perform fine movements of instruments with greater precision, and the ability to achieve a tamponade effect within a vessel using CO_2, all of which are made possible by RALRP(19).

When a surgeon has superior visualization of the peri-prostatic anatomy and more precise instrument control using RALRP, complications associated with these procedures will decrease significantly. In the present cases, surgical laceration occurred in two of 330 cases (0.6%). The affected organ in both cases was the rectum, which correlated with advanced tumors and prior radiation(20,21).

However, comparing the length of hospital stay with those reported in previous studies(22,23), the present data reveal much longer stays. This is likely to be influenced by several factors, including socioeconomic status, anxiety, patient pain tolerance, and other disease complications.

Oncological control is one of the supreme goals for prostate cancer patients who have undergone RP, and can be measured by PSM, biochemical recurrence (BCR) rate, time to BCR, local recurrence, and distant metastasis[24,25]. Wu et al[26] have shown that a PSM in prostate cancer is considered an adverse oncologic outcome, associated with an increased likelihood of BCR. The PSM rate is determined by surgical technique (abilities, experience, and nerve sparing procedure), patient characteristics (e.g., BMI), and tumor factors (e.g., prostate volume and disease extension)[14]. The results of the present study were that, overall, pT2 and pT3 PSM were 38% (125 of 330), 21.9% (40 of 183) and 59% (85 of 144), respectively. The PSM of pT2 stabilized and significantly decreased after 100 cases had been performed, which correlated with the results of previous studies[27,28]. However, the author observed no correlation between the surgeon's experience and PSM in pT3. This may be explained by the findings of a large study (2,206 cases) by Thompson et al[15], which showed that PSM will reach a plateau after 360 cases and will decline only after 606 cases.

Since RALRP is a relatively new procedure, physician faced several initial challenges, including a lack of haptic feedback and a low caseload due to the high initial and procedural costs. The learning plateau was reached after the initial 50 cases, at which point the median operative time and EBL were significantly lowered by 32.5 minutes and 100 ml, respectively. Furthermore, the PSM rate in pathologically organ-confined disease (pT2) improved significantly after 100 cases.

The strength of the present study is its dependence on the experience of a single surgeon. This eliminates the possibility of bias associated with combined results from different surgeons with dissimilar learning curves. Additionally, the present study represented reality more accurately, in terms of patient characteristics, and the higher proportion of advanced-disease and high-risk patients that undergo RALRP in developing countries. Nevertheless, the present study had certain limitations. First, it was a retrospective study that analyzed the data from a single surgeon using the da Vinci Surgical System's Si model (TME-Si). Therefore, the present results may not be applicable to other RALRP series. Second, the data related to functional outcomes, such as erectile dysfunction and incontinence, were not observed to determine outcomes, as the present study was conducted retrospectively. A prospective, randomized study with a larger case volume would prevent the occurrence of bias and yield a significantly more accurate result.

Conclusion

The author concluded that the peri-operative outcomes and PSM rates of RALRP are promising. The initial learning curve was approximated to consist of 100 cases before the surgeon could adequately master the skills required to decrease operative time, EBL, and PSM rates significantly.

What is already known on this topic?

RALRP has been used in Thailand for the last six to seven years. It demonstrated promising result in treatment of prostate cancer all over the world. However, few studies in Thailand reported the result and learning curve of this new technique.

What this study adds?

Peri-operative outcomes and PSM rate of RALRP are promising. The initial learning curve was approximated to be 100 cases for surgeon to adequately master the required skills that decreases operative time, EBL, and increases rate of PSM significantly.

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Conflicts of interest

The author declares no conflict of interest.

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