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Learning Curve of an Innovative "3-Port" Laparoscopic Radical Prostatectomy: A Single-Center Analysis from 2016 to 2019

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Learning curve · Three-port · laparoscopy · Radical prostatectomy

Abstract
Background: "Three-port" laparoscopic radical prostatectomy (LRP) has been applied as a substitution for the conventional 4- to 5-port LRP to treat prostate cancer (PCa) patients in our institution. ***Objective:*** To evaluate the learning curve of an innovative "3-port" LRP for PCa patients. ***Methods:*** 206 patients who received "3-port" LRP were retrospectively reviewed between January 2016 and December 2019 at our institution. According to the different years of operations performed, all of the patients were divided into group A (No. 1–50), group B (No. 51–107), group C (No. 108–160), and group D (No. 161–206). A learning curve was depicted by analyzing the parameters of operative time (OT), estimated blood loss (EBL), hospitalization, and drainage indwelling days. ***Results:*** All groups were comparable with regard to the preoperative characteristics ($p > 0.05$). The sloping learning curve for the surgeon showed that OT and EBL were strongly correlated with an accumulated experience when compared between group A and the other groups ($p < 0.05$), denoting that the surgical skill of the "3-port" LRP can be fully mastered after around 50 cases. Although no significant correlation with additional experience was observed in the hospitalization and drainage indwelling days among groups, a tendency towards less hospitalization and drainage indwelling days was still reflected. ***Conclusions:*** Our 4-year analysis based on a single-center experience exhibits that the innovative "3-port" LRP appears to be favorable with decreasing tendency in OT and EBL with experience accumulation. In view of its advantage of perioperative parameters with an evidently improved learning curve, it should be recommended in the clinical practice!

Introduction

Prostate cancer (PCa) is a disease most frequently occurring among the male patients worldwide, only second to lung cancer with a global, age-standardized incidence rate of 31.1% [1]. In 2012, an estimated 1.1 million men

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were diagnosed with PCa – accounting for 15% of all cancers diagnosed in men at that time [2]. The effective surgical treatment for the early stage of PCa includes open radical prostatectomy, laparoscopic radical prostatectomy (LRP), and robotic-assisted radical prostatectomy (RARP).

With the progress and improvement of the technology, RARP has gradually surpassed the traditional open radical prostatectomy and LRP, and thus been performed as a first-line treatment in several high-volume centers [3]. However, the obvious shortcomings of huge costs must be addressed when patients and doctors are choosing the detailed surgical technique because it has been identified that some patients undergoing robotic surgery might report dissatisfaction and regret in view of the prices [4]. Sugihara et al. [5] have warned that the high total cost of RARP must be kept in mind, and Bolenz et al. [6] also cautioned that the use of robotic technology was increasing without a mature assessment of cost-effectiveness.

In China, the conventional LRP still occupies the majority, which also occurs in some developing countries [7]. The traditional 4- to 5-port LRP will undoubtedly continue to exist in a long run due to its relatively low price [8]. Nevertheless, the mismatch and nontacit understanding between the surgeon and the assistant, the damage caused by the increase of trocars, and the decline of the esthetic degree prompt us to continue to improve the surgical technique. To ensure a maximum health gain at the lowest additional cost, the 3-port LRP is simply an innovative technique that we modified. In this trial, our aim is to evaluate the learning curve of an innovative "3-port" LRP for PCa patients.

Methods

206 patients of PCa receiving surgical treatment were retrospectively reviewed. The inclusion criteria included the following: (1) all of the patients were confirmed by a prostate puncture biopsy with the assistance of magnetic resonance imaging preoperatively, (2) the operation was performed between January 2016 and December 2019 at our institution, (3) it was operated by a single surgeon (Dr. Qian Z), (4) the operation was completed only by 3 trocars judged according to the medical records, and (5) no additional trocar was added in the total process of an operation. The exclusion criteria included the following: (1) the medical record was fragmentary with incomplete perioperative characteristics (age, BMI, prostate volume, prostate serum antigen level, Gleason Score, operative time [OT], estimated blood loss [EBL], drainage indwelling days, hospitalization days, surgical complications, postoperatively pathological stages, and positive surgical margin), (2) patients who had undergone neoadjuvant androgen deprivation therapy, (3) patients with preoperatively suspicious lymph node metastatic disease, (4) patients with previously major abdominal surgery, (5) patients with a history of transurethral resection of the prostate, (6) patients who received sexual nerve-protection operation, and (7) salvaged LRP after radiation therapy.

After selecting patients according to the above criteria, a series of 206 patients was incorporated into the analysis of the learning curve. According to the different years of operations performed, all of the patients were divided into group A (No. 1–50), group B (No. 51–107), group C (No. 108–160), and group D (No. 161–206). Group A consisted of 50 patients (24.3%), group B consisted of 57 patients (27.6%), group C consisted of 43 patients (20.9%), and group D consisted of 56 patients (27.2%). To evaluate the learning speed of the "3-port" LRP, a learning curve was depicted by analyzing the parameters of OT, EBL, hospitalization, and drainage indwelling days among groups.

R (version 4.02) software was used for statistical analysis. Categorical variables were summarized as the frequency and percent and continuous variables summarized as the mean ± standard deviation. The Fisher's exact test and χ^2 test were performed to investigate the existence of a relation between the variables. Pearson correlation analysis was performed to ascertain the relationship in each group, and ANOVA was performed to verify the statistically significant difference among the groups. The statistical significance level for each hypothesis was established at 0.05.

Results

The detailed patient preoperative demographics are listed in Table 1. The categorical variable of "clinical stage" was compared using the χ^2 test, with the continuous variables of "age, BMI, prostate serum antigen, and prostate volume" compared using ANOVA among the 4 groups. The groups were comparable with regard to all of the preoperative characteristics ($p > 0.05$).

In Table 2, the intraoperative parameters including OT, EBL, hospitalization, and drainage indwelling days were reflected. There were no severe complications. The mean OT, EBL, hospitalization, and drainage indwelling days in the amount of 206 patients were 100.0 min, 113.4 mL, 4.5 d, and 3.5 d, respectively. In group A, the corresponding values of these parameters were 139.1 min, 179.2 mL, 4.7 d, and 3.6 d, respectively. In group B, the corresponding values of these parameters were 92.7 min, 99.7 mL, 4.5 d, and 3.4 d, respectively. In group C, the corresponding values of these parameters were 87.7 min, 94.5 mL, 4.2 d, and 3.2 d, respectively. In group D, the corresponding values of these parameters were 82.0 min, 83.0 mL, 4.7 d, and 3.7 d, respectively.

By analyzing these data above in Figure 1, it was shown that the OT and EBL decreased with the passage of years. The ANOVA presented a p value <0.05 for the variables OT and EBL when compared between group

Table 1. The preoperative demographics of 206 patients

Group	Cases	Age, years	BMI	PSA	Prostate volume, mL	Clinical stage (%)			
						cT2a	cT2b	cT2c	cT3a
Overall	206	66.6±5.1	24.6±3.6	17.6±7.7	32.1±9.7	3 (1.5)	18 (8.7)	170 (82.5)	15 (7.3)
A	50	66.3±5.4	25.6±2.9	17.5±11.9	35.1±15.5	2 (4.0)	4 (8.0)	40 (80.0)	4 (8.0)
B	57	67.6±4.6	24.0±3.9	17.8±6.3	31.1±6.5	0 (0.0)	5 (8.8)	47 (82.5)	5 (8.8)
C	43	66.7±5.2	23.9±3.6	17.5±5.2	31.9±7.0	0 (0.0)	2 (4.7)	38 (88.4)	3 (7.0)
D	56	65.6±5.2	24.7±3.6	17.6±6.0	30.7±6.5	1 (1.8)	7 (12.5)	45 (80.4)	3 (5.4)
p value		0.229	0.07	0.996	0.088	0.717			

PSA, prostate serum antigen.

Table 2. The intraoperative parameters of 206 patients

	Overall	Group_A	Group_B	Group_C	Group_D	*p* value
Cases	206	50	57	43	56	
OT, min	100.0±36.9	139.1±33.7	92.7±28.8	87.7±25.7	82.0±28.6	<0.001
EBL, mL	113.4±68.0	179.2±74.0	99.7±48.5	94.5±61.3	83.0±41.7	<0.001
Hospital stay, days	4.5±1.2	4.7±1.7	4.5±0.9	4.2±1.0	4.7±0.9	0.118
Drainage, days	3.5±0.9	3.6±1.2	3.4±0.9	3.2±0.9	3.7±0.8	0.075
Clinical_stage (%)						
pT2b	16 (7.8)	2 (4.0)	6 (10.5)	1 (2.3)	7 (12.5)	0.504
pT2c	126 (61.2)	27 (54.0)	35 (61.4)	30 (69.8)	34 (60.7)	
pT3a	36 (17.5)	12 (24.0)	9 (15.8)	7 (16.3)	8 (14.3)	
pT3b	28 (13.6)	9 (18.0)	7 (12.3)	5 (11.6)	7 (12.5)	
Gleason score (%)						
<7	36 (17.5)	8 (16.0)	11 (19.3)	8 (18.6)	9 (16.1)	0.979
>7	21 (10.2)	6 (12.0)	4 (7.0)	5 (11.6)	6 (10.7)	
7	149 (72.3)	36 (72.0)	42 (73.7)	30 (69.8)	41 (73.2)	
PSM (%)						
Negative	159 (77.2)	36 (72.0)	44 (77.2)	34 (79.1)	45 (80.4)	0.76
Positive	47 (22.8)	14 (28.0)	13 (22.8)	9 (20.9)	11 (19.6)	

OT, operative time; EBL, estimated blood loss; PSM, positive surgical margin.

A and the other groups. However, the difference among the other 3 groups was not notable. Of particular note, OT and EBL improved markedly in the first year (group A) and the second year (group B). We applied the Pearson correlation analysis to investigate the relationship in each group and the ANOVA to compare the difference between each group. For the variable OT, the coefficients were −0.35 and −0.24, and the *p* values were 0.01 and 0.04, respectively, in group A and group B. For the variable EBL, the coefficients were −0.43 and −0.29, and the *p* values were 0.002 and 0.03, respectively, in group A and group B. No correlation of OT and EBL was detected in group C and group D. These data denoted that the surgical skill of the "3-port" LRP could be fully mastered after around 50 cases, and some improvement could also be obtained as for OT and EBL in the second year. After 2 years of experience, the surgeon could perform the surgery with relatively stable OT and EBL. Although no significant correlation with additional experience was observed in the hospitalization and drainage indwelling days among groups, a tendency towards less hospitalization and drainage indwelling days was still reflected.

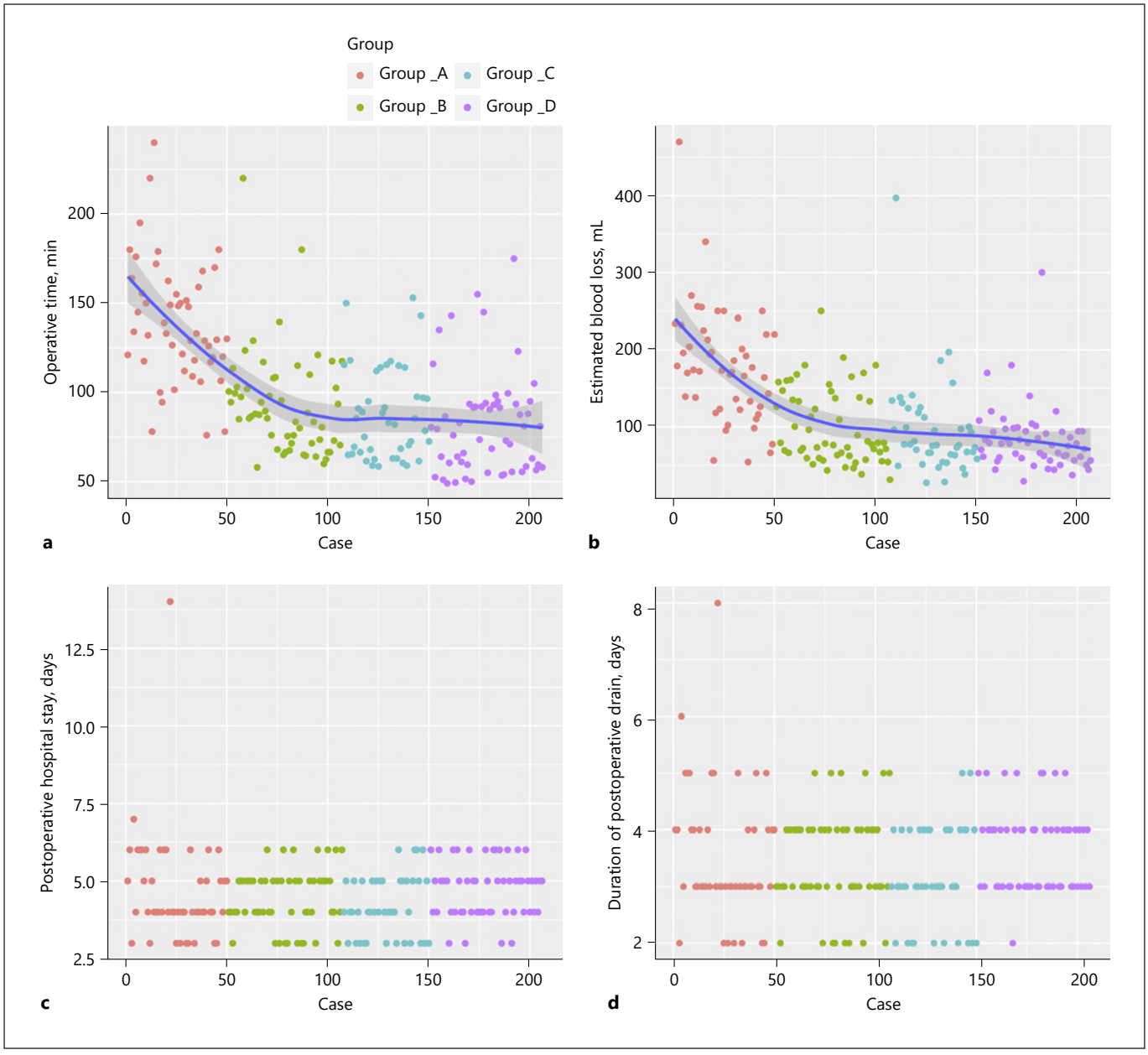

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Fig. 1. A learning curve of "3-port" LRP by comparing the parameters among different groups. OT (**a**), EBL (**b**), postoperative hospital stay (**c**), and duration of postoperative drain (**d**). OT, operative time; EBL, estimated blood loss.

Discussion

Conventional LRP was first introduced as a minimally invasive treatment for PCa in 1991 [9], and since then minimally invasive approaches for PCa treatment have been widely disseminated in an attempt to decrease morbidity [10]. The benefits include smaller incisions, less pain, reduced morbidity, and an overall increase in patient satisfaction. With the increased emphasis on the minimal invasion, single-port LRP and RARP were developed and applied in the clinical practice. Gao et al. [11] reported a similar result using single plus 1-port LRP for PCa, but the obstacles of loss of triangulation and the increased cost of disposable single-port elements were still

present. Although some surgeons advocate single-port LRP and RARP for excellent cosmetic outcomes, it is not a key surgical parameter for an operation of RP that is usually performed in an elderly patient population. Delongchamps et al. [12] reported that scars generated by RP were not different from the patient point of view, and the cosmetic aspect of scars did not seem to be a concern in patients undergoing RP. As a matter of fact, scars indeed had a low impact on overall satisfaction during postoperative patient counseling.

To overcome limitations, including the extended OT and financial burden of RARP, a narrow operating space with an increased risk of complications of single-port LRP, and a loss of triangulation without efficient cooperation by 3 unfamiliar surgeons of the conventional 4- to 5-port LRP, our team modified the conventional LRP technique and now performs 3-port LRP as our first-line treatment for PCa.Gozen et al. [13] have proposed that trocar placement is an important step at the beginning of LRP. Thus, it may affect the continuum of the surgical procedure. As a matter of fact, the extraperitoneal approach is surely not the best approach to use the fourth port extensively due to the limited space. Only in this situation can the most challenging steps including the suturing ligation of the DVC and urethra-vesical anastomosis be performed well.

In order to provide a reference for doctors preparing to perform "3-port" LRP in the future, thus exploring the correlation between perioperative parameters and the number of surgical cases, we conducted this investigation to analyze the 4-year learning curve. In this trial, we divided the 4 years' PCa patients into 4 groups according to the different years of operations performed by the same surgeon in a single center. The results showed that with the increase in the number of surgical cases, the OT was remarkably shortened with the EBL significantly reduced. Especially, after around 50 cases, the surgeons can break through the bottleneck of a learning curve and thus make a qualitative leap. With the accumulation of experience, even if the surgeons spend the initial 50 cases of the learning curve, a significant tendency towards less OT and EBL could still be realized when performing 50–100 cases.

To explain the phenomenon, we believe that mainly due to the lack of direct assistance of the assistant, the surgeon needs to frequently replace the aspirator and forceps at the beginning of the operation, sucking blood timely to make the surgical field clean. With the constant familiarity with anatomy and the constant adaptation of human biofeedback mechanics, the bleeding will be reduced after undergoing the learning curve. Thus, the frequent replacement of equipment can be prevented, and the mutual interference between the assistant and the surgeon can be effectively avoided. As a result, the OT will be shortened. As is well known, prolonged OT is associated with an increased risk of complications in PCa patients [14]. Therefore, shortened total OT should be always pursued, and it can be effectively achieved in our method after undergoing the learning curve although the OT is more likely related to the surgeon's experience [15, 16]. Unluckily, the correlation between the indwelling days of drainage tube and the length of hospital stay was not significant, mainly due to many influencing factors, including postoperative nursing, early postoperative time to the ground, and even medical insurance policy. Moreover, during the traditional 4–5 LRP period, due to the implementation of the fast track surgery in our center, the above indicators of indwelling days of drainage tube and the length of hospital stay were already short, which might explain the reason that there was no statistical significance after the implementation of "3-port" LRP.

Admittedly, our study has several limitations, and our findings must be interpreted in this context. First of all, this study is retrospective. Secondly, the experience was obtained purely based on a single high-volume surgeon at a single center, which means that a limited experience may not be reproducible by all surgeons, and a larger-scale research study requiring collaboration of multiple institutions or even different countries is still needed. We strongly remain hopeful that future research will provide interesting information that can influence the development of surgical methods.

Conclusion

Our 4-year analysis based on a single-center experience exhibits that the innovative "3-port" LRP appears to be favorable with decreasing tendency in OT and EBL with experience accumulation. In view of its advantage of perioperative parameters with an evidently improved learning curve, it should be recommended in the clinical practice!

Statement of Ethics

This research complies with the guidelines for human studies, and the research was conducted ethically in accordance with the World Medical Association Declaration of Helsinki. The investigation was approved by Peking University First Hospital.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

Ben Xu and Bing-lei Ma carried out the design of this research, analyzed and interpreted the data, and drafted the manuscript. Yi-ji Peng participated in the collection of data and data analysis. Qian Zhang assisted in the design of this research and project development. All authors read and approved the final manuscript.

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