A Novel "Three-port" Trocar Placement Technique for Laparoscopic Radical Prostatectomy

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Abstract

Background: To introduce a novel "three-port" trocar placement technique for laparoscopic radical prostatectomy (LRP) in prostate cancer (PCa) patients.

Methods: We retrospectively reviewed 300 patients with PCa who received surgical treatment between November 2010 and June 2015 at our institution. They were divided into group A: three-port LRP, group B: conventional four-five port LRP, group C: open RP (ORP) and group D: robotic-assisted RP (RARP). A learning curve was analyzed by dividing patients of group A into the early and late stages.

Results: All groups were comparable with regard to the preoperative characteristics except for the relatively smaller prostate volume in group A. The three-port LRP operations were performed successfully with only 8 cases conversion to the conventional LRP. None of any severe complications or conversion to ORP occurred. In group A, the mean operative time (OT) duration was 113.8 min, the mean estimated blood loss (EBL) was 94.2 ml, the mean drainage days was 4.0d, the mean hospitalization was 5.1 d, and 27.8% of the prostate specimen margins (PSM) were positive. The differences of OT, EBL, drainage days, hospitalization and transfusion in group A were statistically significant among the majority of the other groups ($p<0.05$). After undergoing the early stages of a learning curve analysis in three-port LRP, the EBL was obviously decreased.

Conclusions: Three-port LRP is a novel technique that exhibits superior intraoperative advantages to the conventional LRP. Due to its less OT, EBL, drainage days, hospitalization and transfusion with a shorter learning curve, it should be recommended and popularized in the clinical practice!

Background

PCa is a disease most frequently among the male patients worldwide, only second to lung cancer with a global, age-standardised incidence rate of 31.1% [1]. In 2012, an estimated 1.1 million men were diagnosed with PCa - accounting for 15% of all cancers diagnosed in men at that time [2]. The incidence of PCa in China is much lower than that in western countries but has increased dramatically in recent years [3]. Satisfactory therapeutic effects for PCa at early stages of disease can be achieved through RP, including ORP (perineal or retropubic), LRP (peritoneal or extraperitoneal) and RARP.

Because the initial RARPs were performed in the United States and Germany in 2000 [4, 5], RARP has gradually surpassed the traditional ORP and been applied extensively as a first-line treatment in several high-volume centers with improved perioperative and functional outcomes without compromising cancer control [6]. Although a high percentage of PCa patients are treated with RARP in the United States (86%), the costs associated with RARP are still too high. This challenge is what many urologic surgeons face in relatively poor and underdeveloped countries. As a matter of fact, patients undergoing robotic surgery report dissatisfaction and regret after the operation [7]. Toru Sugi et al [8] has warned that the high total cost of RARP must be kept in mind and Bolenz et al [9] also cautioned that the uses of robotic technology was increasing without a mature assessment of cost-effectiveness.

In China, the introduction of robotic systems appears to be sparse compared with that in western countries. The conventional LRP still plays an important role in China, which has the majority of PCa patients among different countries. The situation is also nearly the same in the other developing countries [10]. Therefore, the conventional four-five port LRP might likely continue to exist for many years to come due to its cost [11] despite the fact that more advanced and minimally invasive techniques based on the conventional LRP has emerged, such as the single-port LRP. However, the extended OT and narrow operating space with an increased risk of complications limit the extensive application of this procedure. To ensure a maximum health gain at the lowest additional cost, we modified different laparoscopic techniques for PCa. The three-port LRP is simply a modified technique that we improved and which exhibits superior perioperative advantages when compared with other minimally invasive options. In this investigation, our aim was to assess the safety, feasibility and advantages of the procedure, which may evolve to be as common as the conventional LRP after continued adaptations. To our knowledge, we are the first to report this novel "three-port" trocar placement technique for LRP.

Methods

Between November 2010 and June 2015, we retrospectively reviewed the records of PCa patients at our institution at the Peking University First Hospital. A total of 300 patients receiving the surgical treatment (three-port LRP, the conventional four-five LRP, ORP and RARP) were selected after obtaining approval and ethical standards from our institutional review board (Peking University First Hospital). Among them, three-port LRP and the conventional LRP were both operated by a single surgeon (Dr. Qian Z). Patients who had undergone previous major abdominal surgery, metastatic disease, or neoadjuvant androgen deprivation therapy (ADT) or radiation therapy were excluded from the trial. Written informed consent was obtained for all patients. These patients were divided into 4 groups based on the detailed surgical approach applied. Group A (three-port LRP) consisted of 144 patients (48.0%), group B (conventional four-five port LRP) consisted of 88 patients (29.3%), group C (ORP) consisted of 57 patients (19.0%) and group D (RARP) consisted of 11 patients (3.7%). The average age of group A was 66.0 yrs with a mean body mass index (BMI) of 24.2 kg/m^2. The patients with a higher BMI (≥ 26.0 Kg/m^2), a relatively larger prostate volume (≥ 80 ml), or the middle lobe evidently protruded into the bladder were excluded into group A. In our opinions, these above factors may have a negative effect on the clear exposure of the prostate gland and thereby may make the assistant's traction necessary.

Upon admission, the diagnosis was confirmed by a prostate puncture biopsy with the assistance of magnetic resonance imaging (MRI). All of the groups were compared according to perioperative parameters, such as age, BMI, prostate volume, prostate serum antigen (PSA) level, Gleason Score, OT, EBL, drainage days, hospitalization days, surgical complications, postoperatively pathological stages, and PSM among other factors. The OT was calculated from skin incision to the skin closure. The intraoperative EBL was calculated by anesthesiologists. The complications were recorded according to the Clavien-Dindo grading system. The postoperative pathological tumor stage was established according to TNM 2009 [12]. To evaluate the learning speed of the three-port LRP, a learning curve was also analyzed by dividing these 144 consecutive patients into the early stage (72 patients) and late stage (72 patients) according to their surgical periods.

All statistical tests of perioperative data were carried out with the program SPSS v16.0. For statistical analysis, categorical variables were summarized as the frequency and percent. Continuous variables were summarized as the mean ± standard deviation (SD) for normally distributed data. The groups were compared for continuous variables using the independent *t* test and for proportions using the Pearson Chi-square test or Fisher's exact test. The statistical significance level for each hypothesis was established at 0.05.

All of the patients in group A were given exhaustive information regarding the detailed surgical procedure performed by an extraperitoneal approach with only three trocars involved by subtracting an additional incision at the McBurney point. After induction of general anesthesia, the patients were positioned in the safe flat supine position with the operation table placed in the 15°-20° Trendelenburg position. The first step of the procedure was to create an extraperitoneal space and place the first trocar. A sub-umbilical incision (1.5 cm for the prostate volume ≤ 30 ml or 2.5 cm for the prostate volume > 30 ml) was initially made through the skin, subcutaneous tissue and rectoabdominal fascia. Blunt dissection of prevesical space was then created by hand and a handmade balloon system. Afterwards, a 10-mm trocar was introduced gently through this incision, and the extraperitoneal space was then extended carefully up to the pelvis. Under the direct optic vision through this trocar, the other two incisions for trocar placement were performed successively: one on right and one on left lateral margin of the rectus abdominis muscle with a length of 2 finger-breadths below the umbilicus. The operation was performed by only two surgeons (Fig. 1A). The detailed trocar locations were revealed in Fig. 1B-C.

The intraoperative vision, exposure and manipulation could be simply summarized as a "six steps" - "step by step" procedure. (1) The subcutaneous fat was initially cleared to expose the rectus fascia, and the extra-peritoneal space was further enlarged down the pelvis using the Harmonic scalpel exposing the important structures and anatomic landmarks around the bladder and prostatic gland. The bilateral endopelvic fascia was sharply divided, exposing the muscle fibers attached to the lateral and apical portions of the prostate. Then, the prostate was freed in an antegrade fashion from the bilateral surrounding tissue in which the puboprostatic ligament was dissected proximal to the prostate. Afterwards, the dorsal vein complex (DVC) was oversewed using a 1 – 0 polyglycolic acid absorbable suture just distal to the prostate apex (Fig. 2A). (2) After the ligation of DVC, the bladder neck and prostate were separated by scissors. In this step, several methods could be helpful in proper identification of the bladder neck, including (a) the visual identification of the point of transition of the prevesical fat to the anterior prostate, (b) intermittent and repetitive caudal retraction of the urethral catheter balloon and (c) using a forcep to grasp and retract the dome of the bladder in a cephalad direction resulting in "tenting" of the bladder neck at its attachment to the prostate. The anterior bladder was subsequently divided until the urethral catheter was identified and the posterior bladder neck was exposed (Fig. 2B). (3) After the bladder neck transection, the seminal vesicles were individually identified, dissected and divided from 5 to 7 o’ clock of the bladder neck. (4) Afterwards, the anterior retraction of the vasa deferentia and seminal vesicles could help with identification of the proper plane between the prostate and rectum. The Denonvilliers fascia could be subsequently separated from the posterior prostate by careful blunt and sharp dissection until to the prostatic apex and laterally to the prostatic pedicle. Ligasure and bipolar electrocautery could be used for control of the prostatic pedicle (Fig. 2D). (5) Until now, antegrade dissection had allowed complete mobilization of the lateral, basal and posterior prostate, leaving only the urethra from the prostate apex. As much urethral length as possible should be maintained, the prostate apex could be dissected in a retrograde fashion by harmonic scalpel with the Foley catheter extracted from the incision (Fig. 2E). (6) The last but not least, a single needle running suture method for vesicourethral anastomosis developed by Xu Z. et al was usually applied. The technique was initiated by performing a fixed suture at the posterior lip of bladder neck at 3–4 o’ clock and tying the first knot. Another suture at the nearby position of the first suture was performed to leave the first knot outside. From 5–8 o’ clock, sutures were performed every one o’ clock to secure the posterior approximation. After the posterior vesicourethral anastomosis was achieved, a catheter was inserted into the bladder and the anterior vesicourethral anastomosis was performed, which was finally tested by inflow of 100 ml saline to ensure water tightness (Fig. 2F).

After a careful examination of the surgical field, a drain was placed in the pelvis. The specimens were placed in an endobag and retrieved from the incision after removal of the laparoscopic port. The abdominal incisions were finally closed in the usual fashion.

Results

The detailed patient demographics and outcome characteristics are listed in **Table 1**. The groups were comparable with regard to all of the preoperative characteristics, such as age, BMI, smoking history, prostate volume, PSA level and Gleason scores by prostate puncture. The three-port LRP operations were performed successfully with only 8 cases conversion to the conventional LRP. None of any severe complications or conversion to ORP occurred. Only five mild complications (Clavien-Dindo I-II) of postoperative ileus and anastomosis leak occurred, but the patient recovered with conservative methods. In group A, the mean OT was 113.8 min, the mean EBL was 94.2 ml, the mean drainage day duration was 4.0 d, the mean postoperative hospital stay was 5.1 d, and 27.8% of the PSMs were positive. The differences of OT, EBL, drainage days, hospitalization and transfusion in group A were statistically significant among the majority of the other groups (p<0.05). However, the other parameters including postoperative complications, postoperative pathological stages, Gleason scores and PSMs were not significant (p>0.05) among different groups. Above all, group A was associated with a shorter OT, less EBL and blood transfusion, and fewer drainage days and hospitalization.

Table 1
Patient demographics and outcome characteristics of patients among groups

Variables	Group A	Group B	Group C	Group D	p Value	p value after comparison		
						A vs B	A vs C	A vs D
No. patients	144	88	57	11	-	-	-	-
Age (yrs)	66.0±7.1	67.7±6.8	66.5±6.3	68.6±8.5	0.244	-	-	-
BMI (kg/m^2)	24.2±2.6	24.8±2.9	24.6±2.7	23.6±2.9	0.253	-	-	-
Smoking history (%)	16 (11.1%)	15 (17.0%)	6 (10.7%)	2 (18.2%)	0.470	-	-	-
ADT history (%)	16 (11.1%)	5 (5.7%)	1 (1.8%)	1 (9.1%)	0.100	-	-	-
PSA level (ng/ml)	13.4±12.1	15.2±12.6	14.1±27.3	15.2±17.7	0.867	-	-	-
Prostate volume (ml)	35.2±16.0	42.6±26.7	46.7±25.2	36.6±11.5	0.003	0.118	0.013	0.999
Preoperative Gleason scores by puncture (%)								
<7	37 (25.7%)	30 (34.1%)	20 (35.1%)	5 (45.4%)	0.113	-	-	-
=7	88 (61.1%)	38 (43.2%)	28 (49.1%)	4 (36.4%)				
>7	19 (13.2%)	20 (22.7%)	9 (15.8%)	2 (18.2%)				
EBL (ml)	94.2±73.4	216.7±173.2	1247.9±1137.2	150.0±130.4	<0.001	<0.001	<0.001	0.661
OT (min)	113.8±21.1	130.6±30.3	240.1±52.1	214.4±38.8	<0.001	0.002	<0.001	<0.001
Drainage days (d)	4.0±2.6	3.7±2.9	6.4±5.7	4.5±1.6	<0.001	0.973	0.018	0.913
Hospitalization days (d)	5.1±2.9	5.2±3.4	8.8±5.8	6.3±2.5	<0.001	1.000	<0.001	0.647
Transfusion (ml)	0	4.5±42.6	652.6±789.8	0	<0.001	0.897	<0.001	-
Complications								
0	130 (96.3%)	81 (92.0%)	52 (91.2%)	10 (90.9%)	0.104	-	-	-
[illegible]	4 (3.0%)	5 (5.7%)	3 (5.3%)	0				
[illegible]	1 (0.7%)	0	2 (3.5%)	1 (9.1%)				
[illegible]	0	2 (2.3%)	0	0				
Postoperatively pathological stages (%)								
T2	87 (60.4%)	41 (46.6%)	34 (59.6%)	5 (45.5%)	0.161	-	-	-
T3	57 (39.6%)	47 (53.4%)	23 (40.4%)	6 (54.5%)				
PSM (%)	40 (27.8%)	27 (30.7%)	19 (33.3%)	4 (36.4%)	0.792	-	-	-
Postoperative Gleason scores by operation (%)								
<7	10 (6.9%)	9 (10.2%)	8 (14.0%)	1 (9.1%)	0.242	-	-	-
=7	112 (77.8%)	56 (63.6%)	39 (68.4%)	8 (72.7%)				
>7	22 (15.3%)	23 (26.1%)	10 (17.6%)	2 (18.2%)				

Group A: three-port LRP; Group B: conventional four-five port LRP; Group C: ORP; Group D: RARP;

No.=number; BMI= body mass index; ADT= androgen deprivation therapy; PSA= prostate specific antigen; EBL= estimated blood loss; OT= operative time; PSM= positive surgical margin.

After undergoing the early stage of a learning curve analysis in three-port LRP, an improvement in the OT, EBL, drainage days and hospitalization was reflected in **Figure 3**. Among them, the EBL was evidently decreased and was significantly longer for the initial 72 cases than for the next 72 cases. Although the OT, drainage days and hospitalization of the initial 72 cases were not significantly different from those of the next 72 cases, a tendency towards more superior outcomes was still observed in the late stage.

Discussion

Conventional LRP was first introduced as a minimally invasive treatment for PCa in 1991 [13], and since then, minimally invasive approaches for PCa treatment have been widely disseminated in an attempt to decrease morbidity [14]. The benefits include smaller incisions, less pain, reduced morbidity and an overall increase in patient satisfaction. With the improvement of the modern technology and the advent of robotic instruments, RARP was promptly applied mainly in the United States and in some developed European countries as the most common extirpative treatment for PCa [15].

Nevertheless, the increased technical effort with a longer robot docking time and the increased cost associated with the robot-assisted operation cannot be ignored. It has been demonstrated that over 10 years, RARP was on average more costly than LRP [16]. Especially in the developing countries such as China, the healthcare resources are in heavy shortage and medical insurance fails to cover the fees on robot-assisted operations. The high cost has also led a number of authorities to question the value of RARP to patients and health care systems. Unfortunately, this unpleasant situation cannot be improved by the surgeons or the hospital itself, but by the economists and politicians. Therefore, the RARP may not be generalizable to the developing countries and community settings. In developing countries such as China, choosing LRP instead of RARP remains common due to the robotic medical expenses that the national health insurance system does not cover. Factually, the standard laparoscopic technique still continues to be practiced in a number of centers in developed countries due to the higher total hospitalization costs of RARP [17, 18].

As for the extensive application of LRP in developing countries, it can be further divided into the conventional four-five port LRP and a more minimally invasive single-port LRP. Single-port LRP is associated with reductions in the number of transcutaneous access points, reducing incision-related complications and improving cosmesis [19]. However, due to a loss of triangulation, small operative space and instrument clashes [20] with some doubtful factors on the safety of the procedure and the extended OT, concentrating the incisions at a single site limits the range of motion and makes visualization difficult, which is a huge challenge even for an experienced laparoscopic surgeon. Gao Y et al. [3] also reported a similar results using single plus one port LRP for PCa, but the obstacles mentioned above were still present. Although some surgeons advocate this technique for the excellent cosmetic outcomes, it is not a key surgical parameter for an operation of RP that is usually performed in an elderly patients population. Delongchamps NB et al. [21] 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. Additionally, the increased cost related to the use of disposable elements must also be taken into account when considering the application of this technique.

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 three unfamiliar surgeons of the conventional port LRP, our team modified the conventional LRP technique and now performs three-port LRP as our first-line treatment for PCa. Ali SG et al [22] has 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. In our views, three-port LRP combines the advantages of lower cost, faster OT, lower complication rates and acceptable incision cosmesis. Using laparoscopic vision, the surgeon can detect certain features that cannot be realized accurately and vividly by the RARP. Furthermore, the three-port equilateral triangle can avoid a narrow space, which is a remarkable disadvantage when executing single-port LRP. As a matter of fact, three-port LRP is the best combination of direct contact with the surgeon's observations, a spacious cavity and efficient coordination in clinical practice. Only in this situation can the most challenging steps including the suturing ligation of the DVC and urethra-vesical anastomosis be performed well. When compared with the conventional four-five port LRP, other advantages of this approach are heavily emphasized. In three-port LRP, the concept of triangulation implies an instrument positioning schema that provides an optimal relationship between the camera and the working instrument. With the bipolar instrument and the laparoscopic traction forceps both in the surgeon's hand, this setup can promote accurate retraction and rapid hemostasis. Some important procedures, including traction of the adjacent structures, dissecting the surrounding tissues and promoting hemostasis, can be achieved promptly and efficiently only by the surgeon himself. Three-port LRP is a novel technique based on the conventional LRP that can be easily learned by those who have mastered conventional LRP.

Besides, some professionals might believe that surgeons should strive for use of perineal prostatectomy, which is usually recognized as a minimal invasive procedure with the same advantages and outcomes as laparoscopic and robot assisted procedures yet much cheaper and the most cost-effective. Unfortunately, the disadvantages of this technique cannot be ignored, and the popularization may be severely limited due to these reasons as follows: (1) the narrow space with limited exposure makes hemostasis more difficult; (2) Unclear anatomic vision increases the risks of rectal injury; (3) postoperatively, the functional parameters regarding erectile function and urinary continence cannot reflect a satisfactory outcome compared with LRP and RARP; (4) for some cases, it is impossible to perform extended lymph node dissection in view of the limited space, which will undoubtedly make a negative influence on the tumor stage and disease prognosis.

In **Table 2**, combining our three-port LRP data with other urologists' experience, it can be clearly revealed that our mean OT is significantly shorter than that for RARP, single-port and the conventional LRP. As is well known, prolonged OT is associated with an increased risk of complications in PCa patients [23]. 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 to related to the surgeon's experiences [24, 25]. Likewise, the parameters of EBL, drainage days, hospitalization days and the rates of surgical complications are also superior to the other urologists. Contradiction with the published literature, the data of complications and recovery in our investigation appeared more excellent, which can be explained by three points: (1) a more quick recovery time with less trocar placement and incisions, (2) the risks of faulty operation can be decreased evidently due to the inflexible and excessive traction by an inexperienced and unskilled assistant, (3) the triangle operation in accordance with the human engineering principle makes the surgeons feel more comfortable and reduce the fatigue.

Table 2
A synopsis of published series on the surgical treatment of PCa

Reference	Treatment	No. Of patients	OT(min)	EBL(ml)	Drainage days (d)	Hospitalization days (d)	Complications(%)	PSM (%)
Akand M [26] et al	ORP	50	255	602	16.3	9.1	90	30
Caceres F [27] et al	single-port LRP	31	207	258	NA	2.9	19.4	16.1
Zhu G [28] et al	single-port LRP	6	252.5	300	11	NA	33	0
Nakane A [29] et al	two-port LRP	22	259	946	6	NA	NA	40.9
Zhang DX [30] et al	two-port LRP	15	170.1	100.7	5.7	NA	13.3	13.3
Akand M [26] et al	conventional LRP	308	208.5	526	8.2	3.2	27.6	28.6
Papachristos A [31] et al	conventional LRP	100	195	300	NA	2	12	13
Goeman L [32] et al	conventional LRP	550	188	390	5.9	4.6	10.9	31.3
Juan HC [33] et al	conventional LRP	41	294	200	8	10	31.7	24.3
Hruza M [34] et al	conventional LRP	500	256	NA	NA	NA	NA	26.5
Akand M [26] et al	RARP	76	242.6	234	6.8	3.2	13.9	27.8
Papachristos A [31] et al	RARP	100	195	300	NA	2	9	8
Park JW [35] et al	RARP	44	371	220	8	7	NA	20
Pierorazio PM [36] et al	RARP	105	NA	NA	NA	NA	NA	34.3
Drouin SJ [37] et al	RARP	71	199.6	310.7	8.1	4.4	8.4	16.9
Ploussard G [38] et al	RARP	1009	128.9	515.4	8.0	4.0	5.9	31.3
Xylinas E [39] et al	RARP	500	NA	NA	NA	NA	NA	30.0
Tasci AI [40] et al	RARP	1499	181.9	225.4	2.3	2.9	6.1	14.1
Our series	three-port LRP	144	113.8	94.2	4.0	5.1	3.7	27.8

PCa=prostate cancer; ORP=open radical prostatectomy; LRP=laparoscopic radical prostatectomy; RARP=robotic-assisted radical prostatectomy; No.=number; OT=operative time; EBL= estimated blood loss; PSM=prostate surgical margin; NA= not available

Admittedly, our study has several limitations and our findings must be interpreted in this context. First of all, this study is retrospective and non-randomized, which clearly biases subsequent analysis. 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. Though the short-term results are encouraging in three-port LRP, the oncological and functional outcomes in the long-term follow-up is still not clear. We strongly remain hopeful that long-term follow-up of these patients will provide interesting information that can influence the development of future methods. Despite the limitations of this study, the usefulness of comparing the treatment outcomes of three-port LRP versus conventional LRP and other surgical techniques for PCa will raise further questions and stimulate ongoing debate in the field of PCa surgery. Hence, further study is still necessary to validate and extrapolate this application.

Conclusions

In conclusion, three-port LRP is a novel technique, which exhibits superior intraoperative advantages to the conventional LRP. Simultaneously, by making a comparison between three-port LRP with other surgical techniques, due to its less OT, EBL, drainage days, hospitalization and transfusion with a shorter learning curve, three-port LRP should be recommended and popularized in the clinical practice!

List Of Abbreviations

laparoscopic radical prostatectomy (LRP)

prostate cancer (PCa)

open RP (ORP)

robotic-assisted RP (RARP)

operative time (OT)

estimated blood loss (EBL)

prostate specimen margins (PSM)

androgen deprivation therapy (ADT)

body mass index (BMI)

magnetic resonance imaging (MRI)

prostate serum antigen (PSA)

standard deviation (SD)

dorsal vein complex (DVC)

Declarations

- # Ethics approval and consent to participate

All participants have consented to this research and this experiment was approved by Peking University First Hospital.

- # Consent for publication

Yes

- # Availability of data and materials

N/A

- # Competing interests

None

- # Funding

None

- # Authors' contributions

Ben Xu and Cheng Luo carried out the design of this research, analysis and interpretation of data, and drafted the manuscript. Zhuo Liu and Yi-sen Meng participated in the collection of data and data analysis. Li-qun Zhou, Zhi-song He and Jie Jin assisted in the design of this research and project development. Qian Zhang conceived the study, reviewed all of the statistical analysis of the data, and revised the manuscript. All authors read and approved the final manuscript.

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Figures

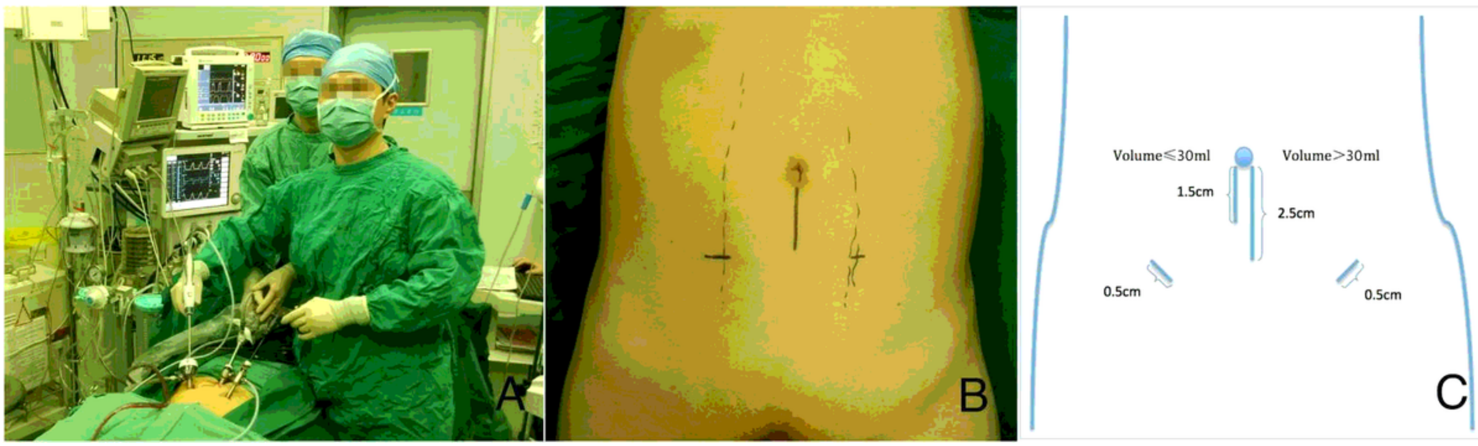

Figure 1

Images of the external cavity. (A) With an assistant holding the laparoscope, the surgeon alone completed all procedures of the operation. (B) Only three trocars were placed, including one just in the umbilical region and two on left/right lateral margin of the rectus abdominis muscle with a length of 2 finger-breadths below the umbilicus. (C) The total lengths of incisions were 1.5+0.5+0.5=2.5cm for the prostate volume (evaluated by preoperative B-ultrasonography) ≤30ml or 2.5+0.5+0.5=3.5cm for the prostate volume >30ml.

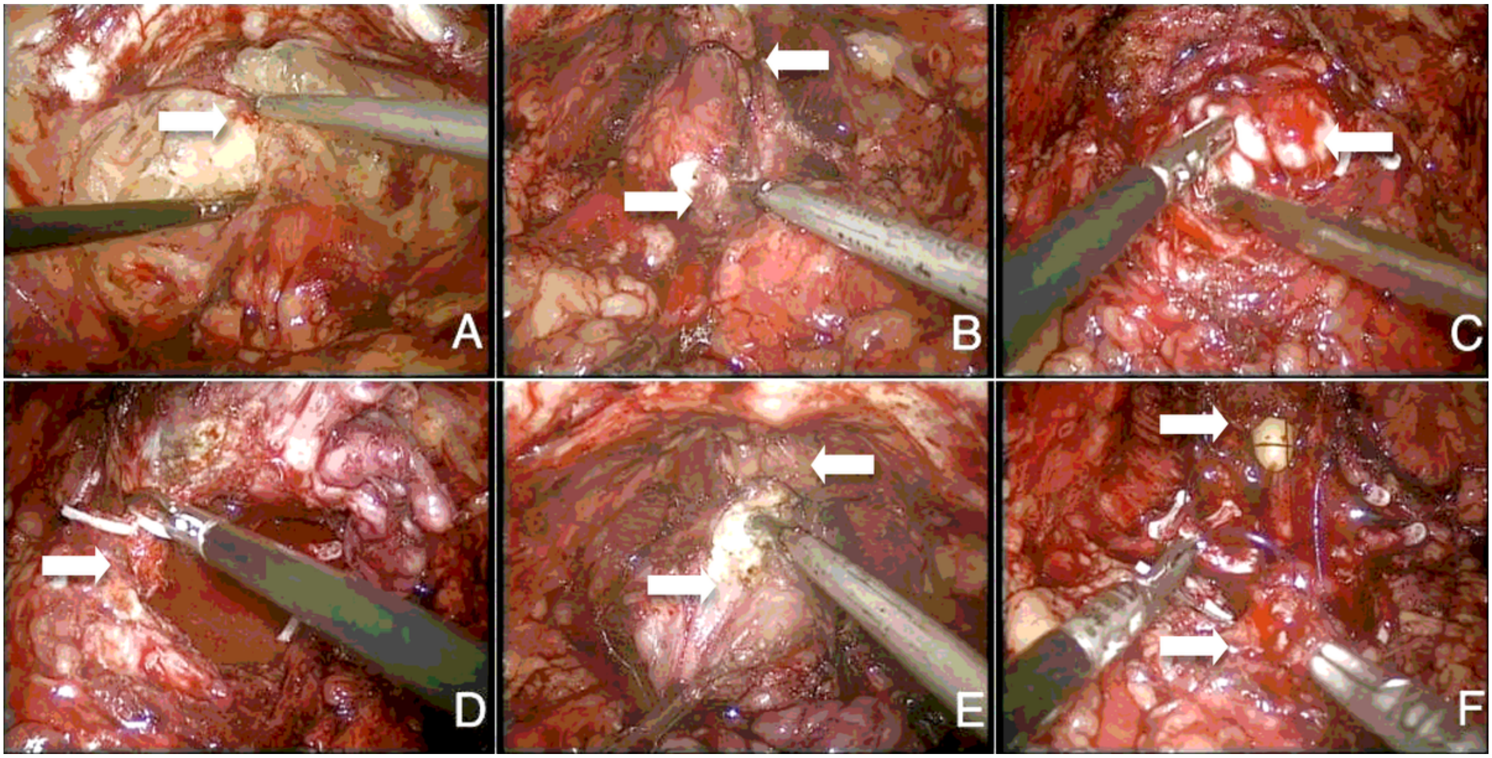

Figure 2

The “six step” - “step by step” procedure. (A) The dissection of the endopelvic fascia (white arrow indicated). (B) The transection of the bladder neck (lower white arrow indicated) after the DVC (upper white arrow indicated) was ligated. (C) The dissection of the seminal vesicles (white arrow indicated). (D) The division of the prostatic pedicle (white arrow indicated). (E) The dissection of prostatic apex (lower white arrow indicated) close to the ligated DVC (upper white arrow indicated). (F) The anastomosis of urethra (upper white arrow indicated) and bladder neck (lower white arrow indicated).

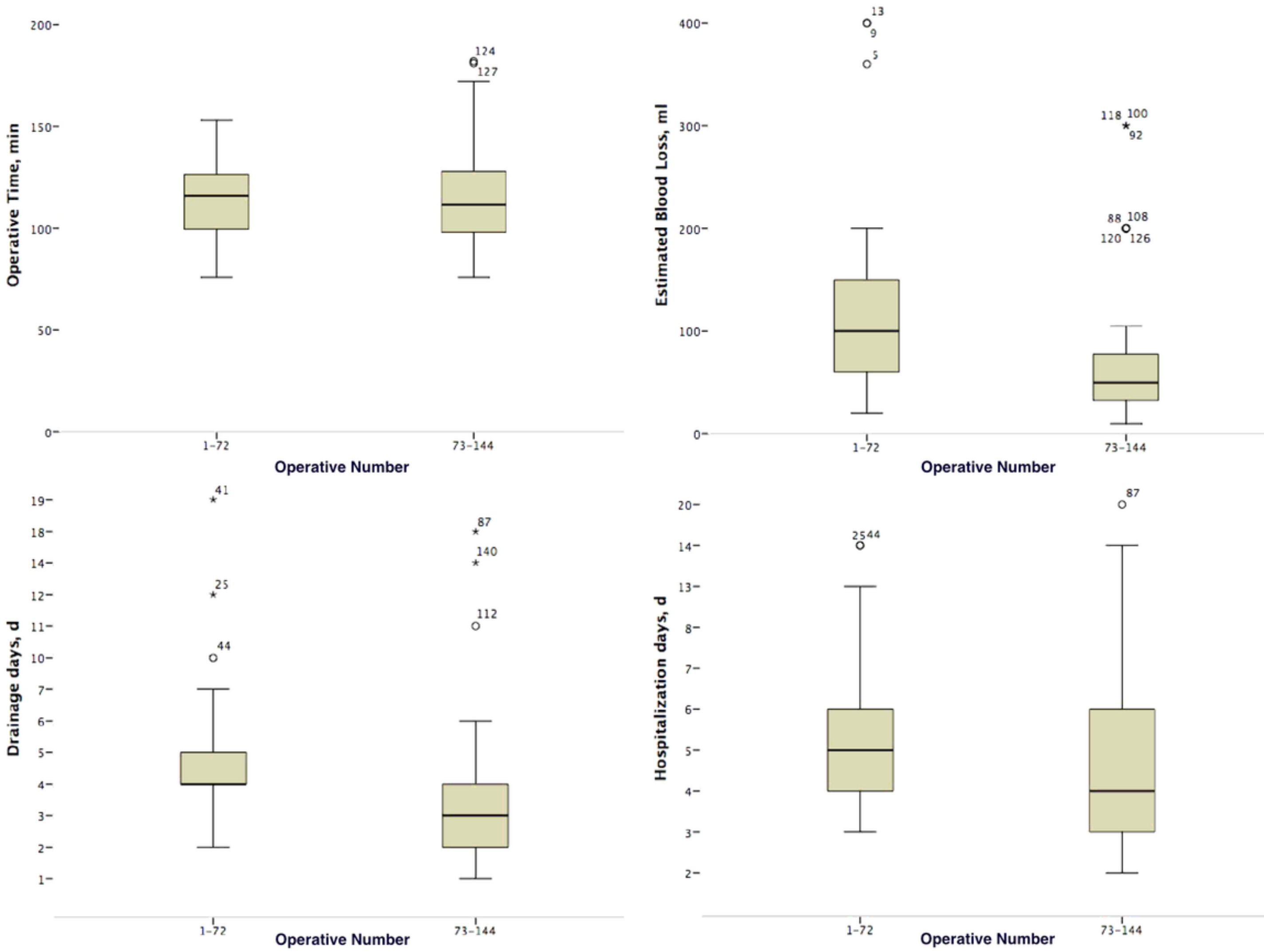

Figure 3

A comparison of three-port LRP between the early stage (initial 72 cases) and the late stage (next 72 cases) for the parameters of OT, EBL, drainage days and hospitalization days.