

Division of dorsal vascular complex using soft coagulation without suture ligation during robot-assisted laparoscopic radical prostatectomy: a propensity score-matched study in a single-center experience

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Introduction Apical dissection and control of the dorsal vascular complex (DVC) affects blood loss, positive surgical margins, and urinary control during robot-assisted laparoscopic radical prostatectomy. Soft coagulation is widely used for hemostasis. However, using soft coagulation to the DVC may affect the continence outcomes. In this study, we described technique and outcomes for division of the DVC after soft coagulation (DVC-SC) compared with delayed ligation of the DVC (D-DVC).

Material and methods Medical records of 170 patients who underwent robot-assisted laparoscopic radical prostatectomy from June 2016 to March 2020 were retrospectively reviewed. To reduce the selection bias, the two groups were matched in a 1:1 ratio on the basis of propensity scores. Perioperative data and results were compared in both groups.

Results Patients undergoing DVC-SC experienced less estimated blood loss compared to patients undergoing D-DVC (median: 105.5 vs 225 ml, $p = 0.017$). Postoperative continence rates at 1 week, 1, 3, 6 months in DVC-SC group and D-DVC group were 32.5% versus 15%, 62.5% versus 32.5%, 85% versus 67.5%, 95% versus 90%, respectively. Continence was significantly better at 1 month with DVC-SC versus D-DVC ($p = 0.013$).

Conclusions Division of the DVC after soft coagulation technique did not affect continence after robot-assisted laparoscopic radical prostatectomy despite the thermal division and gave the surgeon good hemostasis with simple procedure.

Key Words: dorsal vascular complex <> robot-assisted laparoscopic prostatectomy <> soft coagulation

INTRODUCTION

Robot-assisted laparoscopic radical prostatectomy (RARP) has already been performed widely all over the world as a surgical intervention to prostate cancer. At the same time, precise procedures are required to achieve a good oncological outcome and to preserve functions such as urinary continence and erectile function after RARP. A comprehensive tool for assessing outcomes after RARP, the pentafecta is proposed in 2011 [1].

Incision of the dorsal vascular complex (DVC) is a crucial step during the prostatectomy because it affects surgical outcomes. The standard ligature of the dorsal vascular complex (S-DVC) technique has been used to control bleeding since Walsh and Lepor prescribed to ligate the DVC during the first steps of the procedure [2]. On the other hand, this procedure poses risks of injury to the urethra, hurting the external sphincter and decreasing the functional urethral length, and it has been proposed that S-DVC has the possibility to elevate the rate of the

positive surgical margin. Delayed ligation of the DVC (D-DVC) firstly transects the DVC, followed by selective suture ligation of the DVC. D-DVC technique is also widely used in the laparoscopic surgery under pneumoperitoneum [3]. However both techniques are difficult steps for novice surgeons because the S-DVC needs precise needle passage in suturing the DVC and the depth of the stitch for ligation is not always clear [4]. On the other hand, it is necessary to suture precisely and rapidly the DVC under some bleeding in the D-DVC technique.

The VIO® (ERBE Elektromedizim, Tübingen, Germany) soft-coagulation system (SOFT COAG) is an established device for tissue coagulation in which the output voltage is automatically regulated. SOFT COAG is widely used in the fields of bleeding control and is able to be connected with the robotic arms [5]. Therefore, we have attempted to apply the division of the DVC after soft coagulation (DVC-SC), which separates the DVC after coagulating the DVC using the left bipolar SOFT COAG and which does not suture the DVC throughout the surgery. However, there are two main concerns regarding the DVC-SC technique. At first, thermal damage could affect the continence outcomes by using SOFT COAG to the DVC. Second, the absence of DVC suture could result in greater blood loss during and after surgery. Herein, the purpose of our study is to describe an efficient technique for the DVC-SC and to compare clinical outcomes such as safety, urinary control, and oncological outcomes with D-DVC retrospectively.

MATERIAL AND METHODS

This study was carried out following the ethical standards of the Declaration of Helsinki. The ethics review boards of the Fuchu Hospital approved the study (decision no. 2020008).

Since the da Vinci Si system® (Intuitive Surgical, Inc. Sunnyvale, CA, USA) was introduced in our institution in June 2016, 170 men underwent RARP by two surgeons until March 2020. Before surgery, all patients were pathologically diagnosed with prostate cancer by transrectal ultrasound biopsy or transurethral resection. A retrospective analysis of data including patients' preoperative characteristics was conducted by reviewing electronic medical records of patients and surgeries. One surgeon performed 130 consecutive cases using the D-DVC technique from the beginning. Another new surgeon started RARP using the DVC-SC technique in July 2017 and 40 consecutive cases were performed with the technique. All patients who received RARP at our hospital between June 2016 and March 2020 were enrolled in this study, and all patients were analyzed

for no less than 6 months after RARP. One surgeon has been performing the D-DVC technique, and the other has adopted the DVC-SC technique. Therefore, both groups have initial cases and surgeons in each group were completely distinct.

Surgical technique

Common part of the procedure

Prograsp forceps, Maryland bipolar dissector, and curved monopolar scissors are inserted into the robotic forth arm (medial to the right anterior superior iliac spine), and left and right arms, respectively. A bipolar SOFT COAG (50 W, Effect 4) with the left arm/monopolar FORCED COAG system (50W, Effect 3) with the right arm was used to coagulate, using VIO 300D. The procedure was done through a transperitoneal and antegrade approach, almost completely following the technique of Patel and Rocco [6]. The CO₂ insufflation pressure was set to 12 mmHg with the use of the AirSeal® (SurgiQuest, Milford, CT). In case of bleeding intra-abdominal pressure was increased up to 15 mmHg temporarily.

A blunt dissection of the space of Retzius was carried out, sparing the parietal peritoneum and its contents. After entering the retropubic space of Retzius, anterior prostatic fat was removed. The endopelvic fascia was then opened to the pubo-prostatic ligaments and muscle fibers on the surface of the prostate were detached. The same technique was applied to the other side of the prostate. Then, the bladder's anterior and posterior walls were incised at the junction of the prostate and the bladder. The bladder neck preservation technique was not used actively. The vas deferens was then cut to enable recognition and isolation of the seminal vesicle. After sharply incising Denonvilliers' fascia in the midline, the anatomical plane between the prostate posterior capsule and Denonvilliers' fascia was separated. Along this plane, an extrafascial dissection procedure was performed to the apex of the prostate in case of the non-nerve sparing surgery. As a result, all patients in the DVC-SC group and the D-DVC group after matching had non-nerve sparing dissection. The lateral prostatic pedicles were dissected using Hem-o-lok clips® (Teleflex Medical, Durham, NC, USA) to control arteriovenous blanches up to the distal lateral pedicle cord. The DVC was incised and divided by the DVC-SC or the D-DVC fashions as described later until the rhabdosphincter plane was exposed. From the prostatic-rhabdosphincter junction toward the membranous urethra, the striated and smooth muscle fibers were smoothly divided to preserve urethral length. Together with the release of fibrous connections of the prostate at the apex,

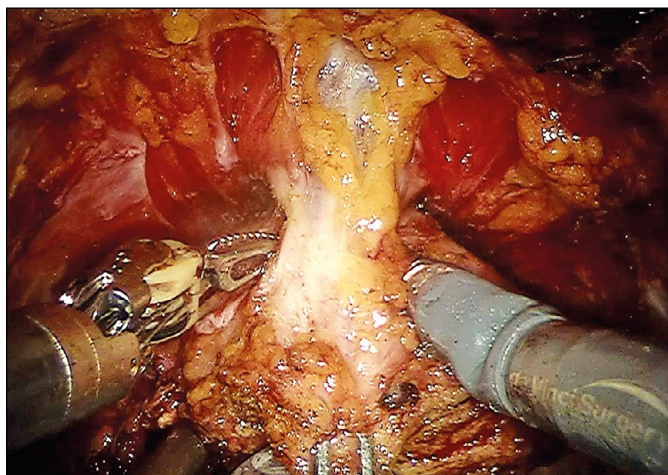


Figure 1. The depth and width of the dorsal vascular complex were confirmed using both arms.

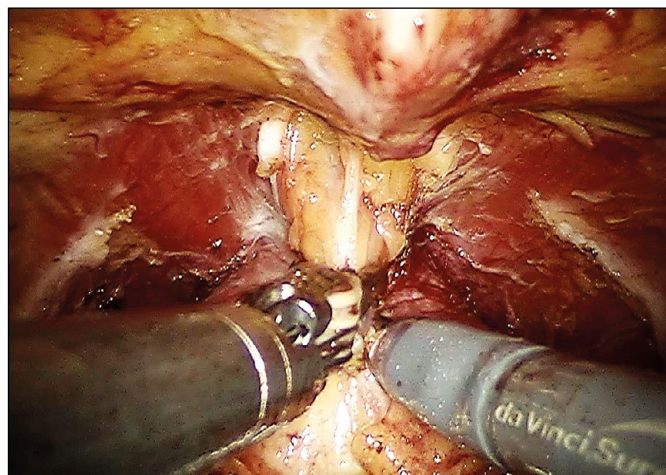


Figure 2. The left Maryland bipolar grasped the dorsal vascular complex with the support of right scissors bracing dorsal vascular complex centrally prior to soft coagulation.

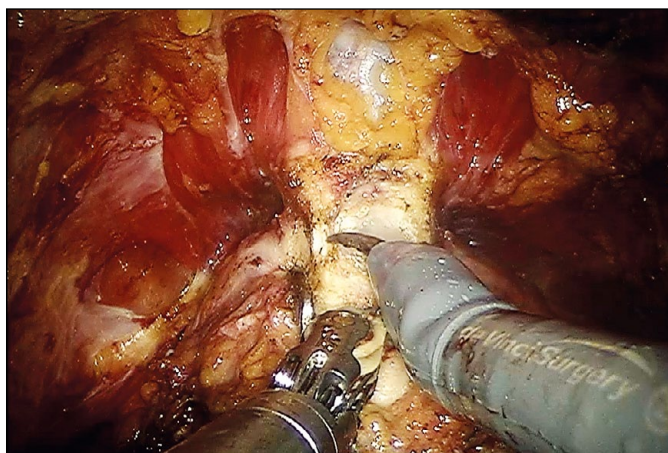


Figure 3. The dorsal vascular complex was transected with the right scissors.

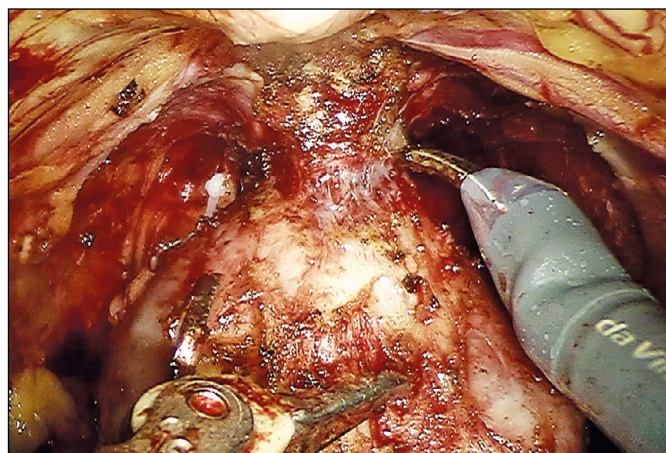


Figure 4. Total dissection of the dorsal vascular complex was performed until the rhabdosphincter plane was exposed.

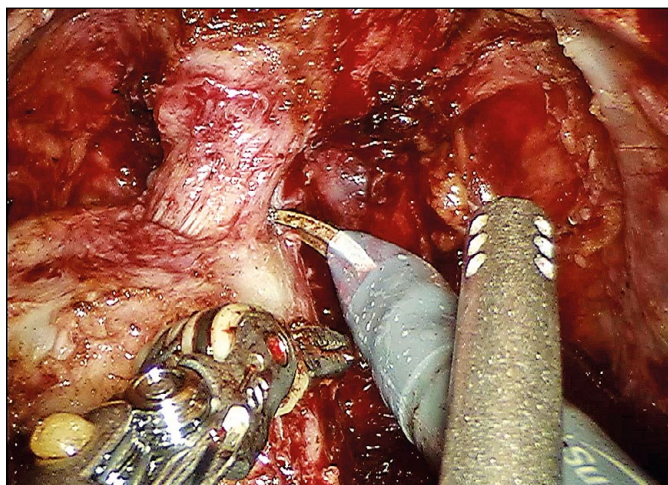


Figure 5. The right side of the apex was dissected under bloodless clear vision after division of the dorsal vascular complex.

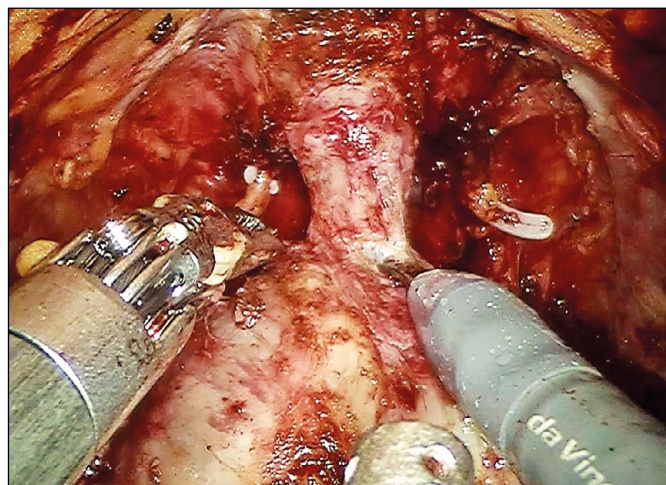


Figure 6. Resection of the urethra.

an additional length of the intra-abdominal urethra was obtained [7]. After removal of the prostate and complete haemostasis, reconstruction of the urinary tract was carried out. Posterior reconstruction was performed following the Rocco stitch. This technique consists of a two-layer reconstruction, the first being the realignment of the sphincteric muscle to Denonvilliers' fascia, followed by a second suture fixing the posterior bladder wall 1–2 cm dorsal and cranial to the median dorsal raphe [8]. Finally, a running vesicourethral anastomosis was achieved by using a 3-0 MONOCRYL® (Ethicon, Cincinnati, OH, USA) on a 17 mm RB-1 needle.

Description of the DVC-SC

The fourth arm Prograsp forceps grasped the base of the prostate and pulled cephalad gently. The left Maryland bipolar grasped the DVC with the support of right scissors bracing the DVC centrally (Figure 1). In case of wide DVC, puboprostatic ligaments were partially divided in order to get better exposure and optimal vision of the DVC. After coagulating the DVC using the left bipolar SOFT COAG, the DVC was transected with the right scissors (Figures 2–4). The right monopolar FORCED COAG was applied as little as possible during this transaction. Rotating the prostate with the fourth arm, the lateral sides of the DVC were incised (Figure 5). When there was bleeding during the incision of the DVC, additional hemostasis was performed by bipolar SOFT COAG or minimal use of monopolar FORCED COAG. By minimizing the bleeding, subsequent apex dissection was performed under better visualization until the urethra was completely exposed (Figure 6). No suture ligation of the DVC was performed at all throughout the surgery.

Description of the D-DVC

The fourth arm Prograsp forceps grasped the base of the prostate and pulled cephalad gently. Athermal, sharp division of the DVC was performed with the minimal use of pinpoint coagulation to arterial hemorrhage. Once the rhabdosphincter plane was exposed anterior to the urethra, the robotic Maryland and the curved scissors were removed and replaced with the needle drivers. A suture ligation to the entire transected stump of the DVC was performed with a 3-0 MONOCRYL on a 17 mm RB-1 needle in a vertical running fashion.

Outcomes

The following variables such as estimated blood loss (EBL), number of transfusions, postoperative pathol-

ogy, duration of catheter indwelling, and hospital days, were considered in the analysis while in hospital. EBL includes urine flowing into the surgical field from the resected margin of the bladder during the operation. Continence was assessed by pad use, and evaluated at 1 week, 1, 3, and 6 months after catheter removal. Continence was defined as 'no need for pads' or '1 security pads/day' without distinguishing between fear of incontinence or small urine leakage [9].

Statistical analysis

Propensity score matching was performed with the nearest-neighbor method at a 1-to-1 ratio based on ten covariates including age, body mass index (BMI), D'Amico risk group, initial prostate-specific antigen (PSA), American Society of Anesthesiology (ASA) score, previous abdominal surgery or transurethral resection of prostate (TUR-P), lymph node dissection, nerve sparing, neoadjuvant androgen-deprivation therapy (ADT), and specimen weight, which will have some influence on the outcomes. Each study group was assigned with 40 patients. Before and after matching, all variables were compared using the Mann-Whitney U-test, t-test or χ^2 test. All P-values of 0.05 or less were considered statistically significant. All statistical analyses were performed with EZR® (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a graphical user interface for R® (The R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Patients' clinical characteristics of DVC-SC and D-DVC groups before and after matching are demonstrated in Table 1. There were no differences in age, BMI, initial PSA, neoadjuvant ADT, previous abdominal surgery or TUR-P, ASA score, or D'Amico risk class between DVC-SC group and D-DVC group. Patients undergoing DVC-SC versus D-DVC experienced less EBL (median: 105.5 vs 225 ml, $p = 0.017$). Moreover, difference of hemoglobin (Hb) values between preoperative and postoperative day 1 (mean: 1.44 vs 1.91 g/dl, $p = 0.046$) in DVC-SC group was less than that in D-DVC group. Blood transfusions were required in 1 of the 130 D-DVC patients (3.1%). After matching, there were no cases of nerve sparing. Lymph node dissection cases, catheterization time and hospital stay were similar in both groups (Table 2).

Table 3 shows the pathologic outcomes in two groups. Positive margin rate was similar (DVC-SC vs D-DVC 17.5% vs 22.5%, $p = 0.781$). Specimen weight was also similar in both groups (mean: DVC-SC vs D-DVC

41.7 g vs 43.6 g, $p = 0.533$). There was no significant difference between the two groups in specimen weight, stage, Gleason score, or positive margin.

Postoperative continence rates at 1 week, 1, 3, 6 months in DVC-SC group and D-DVC group were 32.5% versus 15%, 62.5% versus 32.5%, 85% versus 67.5%, 95% versus 90%, respectively (Table 4). Continence was significantly better at 1 month with DVC-SC versus D-DVC ($p = 0.013$).

DISCUSSION

In this study, we demonstrated the DVC-SC technique for RARP and compared clinical outcomes between the DVC-SC technique and the D-DVC technique in our single-center experience. Blood loss in the DVC-SC technique was less than that in the D-DVC technique. Continence recovery after RARP in the DVC-SC group seemed to be earlier than that in the D-DVC group. And there were no significant differences in

oncological outcome such as rate of positive surgical margins between the two groups. The present study revealed that the DVC-SC technique might be an acceptable procedure for division of the DVC in RARP. During the radical prostatectomy, an anatomical approach for management of the DVC is crucial to recover urinary continence, control bleeding and ensure precise apical dissection [10, 11]. The original description of open retropubic retrograde radical prostatectomy by Walsh and Lepor [2] prescribed to ligate the DVC during the first steps of the procedure, immediately before proceeding to apical dissection. However, the difficulty involved in ligation of the DVC is to find the natural plane between DVC and urethra [12]. As a consequence, the most accepted alternative approach consists of the direct resection of the DVC at the end of prostatectomy, going for suture afterwards. This approach is generally dominated by delayed ligation of the DVC or selective ligation of the DVC (the D-DVC technique) [3]. Li et al. [13] evaluated cur-

Table 1. Patient characteristics

	DVC-SC group	Before matching		After matching	
		D-DVC group	P-value	D-DVC group	P-value
No. of patients	40	130	–	40	–
Age (years), mean ($\pm$ SD)	68.1 $\pm$ (6.2)	68.8 $\pm$ (5.7)	0.510	68.4 $\pm$ (5.2)	0.832
BMI (kg/m ²), mean ($\pm$ SD)	24.3 $\pm$ (3.6)	28.8 $\pm$ (3.0)	0.385	24.7 $\pm$ (3.1)	0.539
Initial PSA (ng/ml), median (IQR)	6.99 (5.05–12.1)	7.98 (5.52–12.84)	0.190	7.66 (5.48–11.75)	0.501
Neoadjuvant ADT, n (%)	2 (5.0%)	16 (12.3%)	0.249	1 (2.5%)	1.000
Previous abdominal surgery or TUR-P, n (%)	9 (22.5%)	23 (17.7%)	0.494	8 (20%)	1.000
ASA score, n (%)					
1	8 (20.0%)	20 (15.4%)	0.724	6 (15.0%)	0.671
2	30 (75.0%)	104 (80.0%)		33 (82.5%)	
3	2 (5.0%)	6 (4.6%)		1 (2.5%)	
D'Amico risk class, n (%)					
Low	17 (42.5%)	60 (46.2%)	0.931	16 (40.0%)	0.895
Intermediate	4 (10.0%)	13 (10.0%)		3 (7.5%)	
High	19 (47.5%)	57 (47.5%)		21 (52.5%)	

DVC-SC – dorsal venous complex soft coagulation; D-DVC – delayed ligation of the DVC; SD – standard deviation; BMI – body mass index; PSA – prostate-specific antigen; IQR – interquartile range; ADT – androgen deprivation therapy; TUR-P – trans-urethral resection of prostate; ASA – American Society of Anesthesiology

Table 2. Perioperative outcomes

	DVC-SC group	Before matching		After matching	
		D-DVC group	P-value	D-DVC group	P-value
Hb change [†] (g/dl), mean ($\pm$ SD)	1.44 $\pm$ (1.17)	1.73 $\pm$ (1.02)	0.126	1.91 $\pm$ (0.93)	0.046
EBL [‡] (ml), median (IQR)	105.5 (93.7–200)	300 (127.5–500)	<0.001	225 (100–450)	0.017
Blood transfusion, n (%)	0 (0%)	4 (3.1%)	0.574	1 (2.5%)	1.000
Lymph node dissection, n (%)	5 (12.5%)	22 (16.9%)	0.625	4 (10%)	1.000
Nerve sparing, n (%)	0 (0%)	3 (2.3%)	1.000	0 (0%)	–
Catheterization time (day), median (IQR)	7 (6–7)	7 (6–7)	0.433	7 (6–7)	0.843
Hospital stay (day), median (IQR)	10 (9–10)	9 (9–10)	0.773	9 (9–10)	0.859

EBL – estimated blood loss; IQR – interquartile range; SD – standard deviation; Hb – hemoglobin

[†]Difference between preoperative and postoperative day1 hemoglobin. [‡]Including urine during an operation.

Table 3. *Pathologic outcomes*

	DVC-SC group	Before matching		After matching	
		D-DVC group	P-value	D-DVC group	P-value
Specimen weight (g), mean ($\pm$ SD)	41.7 $\pm$ (12.6)	47.4 $\pm$ (18.8)	0.072	43.6 $\pm$ (14.3)	0.533
Pathologic stage, n (%)					
T2a	7 (17.5)	14 (10.7)	0.560	2 (5)	0.308
T2b	1 (2.5)	3 (2.3)		2 (5)	
T2c	25 (62.5)	88 (67.6)		29 (72.5)	
T3a	2 (5)	10 (7.6)		2 (10)	
T3b	3 (7.5)	12 (9.2)		2 (5)	
Gleason score, n (%)					
6	3 (7.5)	4 (3.1)	0.583	2 (5)	0.155
3+4	13 (32.5)	38 (29.2)		10 (25)	
4+3	7 (17.5)	39 (30)		17 (42.5)	
8	4 (10)	15 (11.5)		3 (7.5)	
9	13 (32.5)	29 (22.3)		7 (17.5)	
Positive margin, n (%)	7 (17.5)	29 (22.3)	0.659	9 (22.5)	0.781

DVC-SC – dorsal venous complex soft coagulation; D-DVC – delayed ligation of the DVC; SD – standard deviation; n – number of patients

Table 4. *Postoperative continence*

	DVC-SC group	Before matching		After matching	
		D-DVC group	P-value	D-DVC group	P-value
1 week after surgery, n (%)	13 (32.5)	26 (20)	0.131	6 (15)	0.114
1 month after surgery, n (%)	25 (62.5)	59 (45.4)	0.071	13 (32.5)	0.013
3 months after surgery, n (%)	34 (85)	92 (70.8)	0.098	27 (67.5)	0.114
6 months after surgery, n (%)	38 (95)	117 (90)	0.525	36 (90)	0.675

DVC-SC – dorsal venous complex soft coagulation; D-DVC – delayed ligation of the DVC; n – number of patients

rent views on comparing the D-DVC with the S-DVC for safety, urinary control and oncological outcomes during LRP and concluded that the D-DVC could decrease the positive apical margin rate. Therefore, at the initiation of RARP the D-DVC technique was applied to division of the DVC at our institution. However, we sometimes experienced difficulties in controlling the bleeding even under pneumoperitoneum. It would be indispensable to develop an alternative procedure for division of the DVC to the S-DVC and D-DVC techniques. We innovated the DVC-SC technique, which transects the DVC after coagulating the DVC using the left bipolar SOFT COAG and which does not suture the DVC throughout the surgery.

In terms of the perioperative outcomes, The DVC-SC had significantly less EBL and Hb reduction postoperative day 1 than the D-DVC and there was no case of blood transfusion. At the beginning we were concerned about the bleeding during and after RARP without suturing the DVC. But, sufficient hemostasis was provided by coagulation to the DVC using only the VIO system. There are reports that the D-DVC has greater EBL when compared with the conventional S-DVC [13, 14]. Even under the pneumoperitoneum, the thermal division causes hemorrhage in the surgical field to some degree. Subsequent suture

of the DVC under hemorrhage is somewhat hard for a novice surgeon and difficult and prolonged suturing can lead to more bleeding. The DVC-SC has advantages in the apical dissection after the division of the DVC because of clear visualization. However, there was no significant difference between the groups in positive margin rate. Our study suggested that the DVC-SC procedure might be unexceptionable both for safety and for oncological outcome such as positive surgical margin rate.

Generally, to minimize thermal damage to the urethral sphincter, the use of thermal energy is avoided. We were also concerned that by using SOFT COAG to the DVC for haemostasis, continence outcomes after surgery would worsen. However there were two reports about using thermal devices to the DVC, one used an ultrasonic energy device in LRP and the other applied a bipolar vessel sealing device in open radical prostatectomy [15, 16]. And Nishide et al. [17] reported the effectiveness of SOFT COAG for hemostasis to the epidural venous plexus and recommended bipolar SOFT COAG for use in spine surgery, assessing the potential risk of severe neural tissue damage. These reports might not completely eliminate our concerns about thermal damage to the sphincter but support our decision to use

SOFT COAG to the DVC. In this study, we demonstrated that rates of continence at 1 week, 1, 3, and 6 months after surgery were similar between the DVC-SC and D-DVC group. Our study showed that the use of SOFT COAG to the DVC had no significant adverse effect on continence outcome after surgery. On the contrary the effectively controls bleeding, maintaining a clear field of vision, and facilitates identification of the anatomy of the prostatic apex based on the DVC might result in preservation of functional urethral length, and that could lead to better continence. However, it still remains to be seen how much the thermal damage, by using SOFT COAG, actually affects the urethral sphincter.

There are some limitations in this study. First of all, the number of patients is small, and all patients were from a single institute. Second, although the propensity score matching method was used, it is a retrospective study. Third, EBL and continence rates, both

outcomes of the current analysis, can be hugely affected by the surgeon and surgical technique, including, but not limited to, the nerve sparing technique. Several modifications of the standard robotic technique have proven to improve the continence rate [18]. Furthermore, these findings appear to be associated with the surgeon's overall accuracy and precision rather than with a specific technique. A randomized, double-blind, prospective study is needed to validate this hypothesis further in the future.

In conclusion, The DVC-SC that seems a simple surgical procedure might not affect continence after RARP despite the thermal division and be acceptable for safety and for oncological outcome. This technique can be one of the optional procedures for division of the DVC in RARP.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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