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The Impact of Prostate Size, Median Lobe, and Prior Benign Prostatic Hyperplasia Intervention on Robot-Assisted Laparoscopic Prostatectomy: Technique and Outcomes

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Abstract

Background: Large prostate size, median lobes, and prior benign prostatic hyperplasia (BPH) surgery may pose technical challenges during robot-assisted laparoscopic prostatectomy (RALP).
Objective: To describe technical modifications to overcome BPH sequelae and associated outcomes.
Design, settings, and participants: A retrospective study of prospective data on 951 RALP procedures performed from September 2005 to November 2010 was conducted. Outcomes were analyzed by prostate weight, prior BPH surgical intervention ($n = 59$), and median lobes >1 cm ($n = 42$).
Surgical procedure: RALP.
Measurements: Estimated blood loss (EBL), blood transfusions, operative time, positive surgical margin (PSM), and urinary and sexual function were measured.
Results and limitations: In unadjusted analysis, men with larger prostates and median lobes experienced higher EBL (213.5 vs 176.5 ml; $p < 0.001$ and 236.4 vs 193.3 ml; $p = 0.002$), and larger prostates were associated with more transfusions (4 vs 1; $p = 0.037$). Operative times were longer for men with larger prostates (164.2 vs 149.1 min; $p = 0.002$), median lobes (185.8 vs 155.0 min; $p = 0.004$), and prior BPH surgical interventions (170.2 vs 155.4 min; $p = 0.004$). Men with prior BPH interventions experienced more prostate base PSM (5.1% vs 1.2%; $p = 0.018$) but similar overall PSM. In adjusted analyses, the presence of median lobes increased both EBL ($p = 0.006$) and operative times ($p < 0.001$), while prior BPH interventions also prolonged operative times ($p = 0.014$). However, prostate size did not affect EBL, PSM, or recovery of urinary or sexual function.
Conclusions: Although BPH characteristics prolonged RALP procedure times and increased EBL, prostate size did not affect PSM or urinary and sexual function.

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1. Introduction

Following the introduction of prostate-specific antigen (PSA) screening and medical therapy for benign prostatic hypertrophy (BPH), men diagnosed with clinically localized prostate cancer (PCa) have presented with greater prostate size [1]. In addition, because of the increased popularity of active surveillance, those who eventually opt for definitive therapy may be more likely to have concurrent BPH features. Given the limitations of external-beam radiation therapy and brachytherapy with larger prostates [2,3], radical prostatectomy (RP) remains the treatment of choice. However, robot-assisted laparoscopic prostatectomy (RALP) for larger prostates is associated with greater blood loss, longer operative times, and slower return to continence [4–7]. BPH characteristics such as large median lobes increase the difficulty of RALP [8]. Moreover, there are concerns about residual median lobe tissue following RALP because of the absence of haptic feedback with the robotic platform [9].

Technological advances have led to various surgical therapies for BPH, and the sequelae of these interventions may also lead to challenges during RALP. For instance, transurethral resection of the prostate (TURP) increases the risk for positive surgical margins (PSM) during laparoscopic RP (LRP) and RALP [10–12]. Given the difficulties posed by larger prostates and the lengthy RALP learning curve [13], our study objectives are to demonstrate consistently reproducible techniques to overcome BPH-related anatomic variations and to assess outcomes by prostate size and BPH characteristics.

2. Patients and methods

2.1. Enrollment

The institutional review board approved this study, and data were collected prospectively. From September 2005 through November 2010, 951 consecutive men underwent RALP by a single surgeon (JCH) at Brigham and Women's/Faulkner Hospital, including 59 men with previous BPH interventions (53 TURP procedures, two transurethral laser vaporizations, one needle ablation, one transurethral incision of the prostate, and two microwave therapies) and 42 men with prominent median lobes >1 cm in greatest diameter. We biopsied and diagnosed PCa in six men (0.6%), and the majority were diagnosed by outside urologists. We did not perform cystoscopy, urodynamics testing, or repeat prostate ultrasound prior to RALP. Before study initiation, the surgeon logged 397 RALP and 76 radical retropubic prostatectomy cases during fellowship and residency training, respectively.

2.2. Surgical technique

Prograsp forceps, a Maryland bipolar dissector, and curved monopolar scissors are inserted into the robotic fourth arm (medial to the left anterior superior iliac spine), the left arm, and the right arm, respectively [14]. Twelve- and 5-mm assistant ports are placed medial to the right anterior superior iliac spine and in the right upper quadrant, respectively. Energy settings are 25 W for both monopolar and bipolar settings, and the monopolar setting is used sparingly while entering the retropubic space and dividing the posterior bladder neck mucosa. The CO_2 insufflation pressure and flow are set to 15 mm Hg and 10 l/min, respectively. A 0° lens is used throughout the procedure.

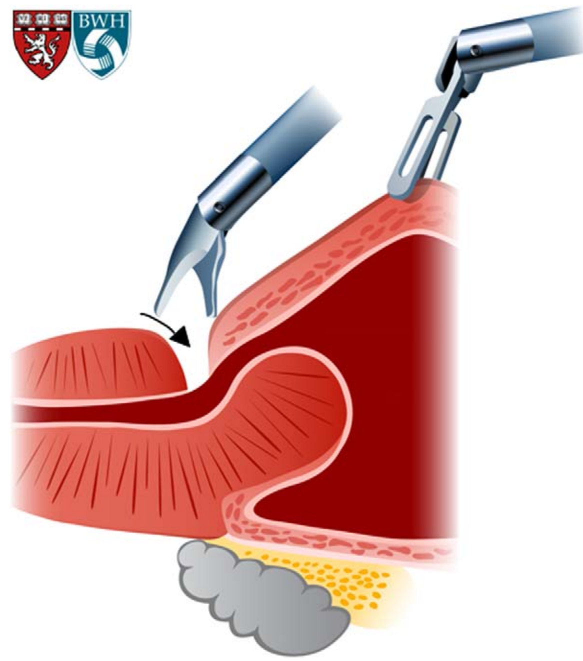

Fig. 1 – The fourth arm tents up the bladder for anterocephalad retraction, and the anterior bladder neck dissection is initiated where the bladder and detrusor apron tenting stops midprostate. Median lobes may attenuate the bladder wall anteriorly. Sharp dissection is used to identify longitudinal fibers of the anterior bladder neck, and the bladder is peeled off of the prostate in the direction of the arrow.

An antegrade approach to RALP is performed, and the bladder neck is preserved when feasible, even with significant BPH, prominent median lobe [15], or positive prostate base biopsies. After seminal vesicle dissection, nerve sparing [16] is performed, followed by apical dissection and division of the dorsal vein complex (DVC) and selective suture ligation (SSL) [17]. Our DVC ligation technique evolved from using the endovascular stapler (Ethicon, Cincinnati, OH, USA) control, to non-SSL before DVC division, to DVC-SSL. When the prostate is completely freed and placed in a specimen bag, the urethrovesical anastomosis is performed with a single interrupted posterior suture and two running 3-0 polyglactin sutures [18,19].

2.2.1. Approach to enlarged prostates, median lobes, and previous benign prostatic hypertrophy surgeries

The fourth-arm Prograsp tents the bladder in an anterocephalad direction to allow identification of the point of incision through the detrusor apron (Fig. 1). Blunt dissection peels the bladder fibers proximally until identification of the longitudinal anterior bladder neck fibers as they funnel to form the prostatic urethra [15]. Emphasis on sharp, cold scissors dissection and preferential use of bipolar over monopolar cautery minimizes tissue char and facilitates differentiation of the bladder fiber texture from the prostate. Wisps of cloudy prostatic secretions with cold cutting indicate when dissection is too distal into the prostate.

When the longitudinal bladder neck fibers are identified, bladder fibers are released from the prostate posterolaterally until reaching prostatovesical fat—a landmark for the lateral prostate pedicle [15]. Asymmetric lateral lobes and/or a median lobe may distort the funneled appearance of the vertical bladder neck fibers by displacing the bladder neck laterally and attenuating the anterior bladder neck, contributing to early inadvertent anterior cystotomy. If this occurs, bladder neck

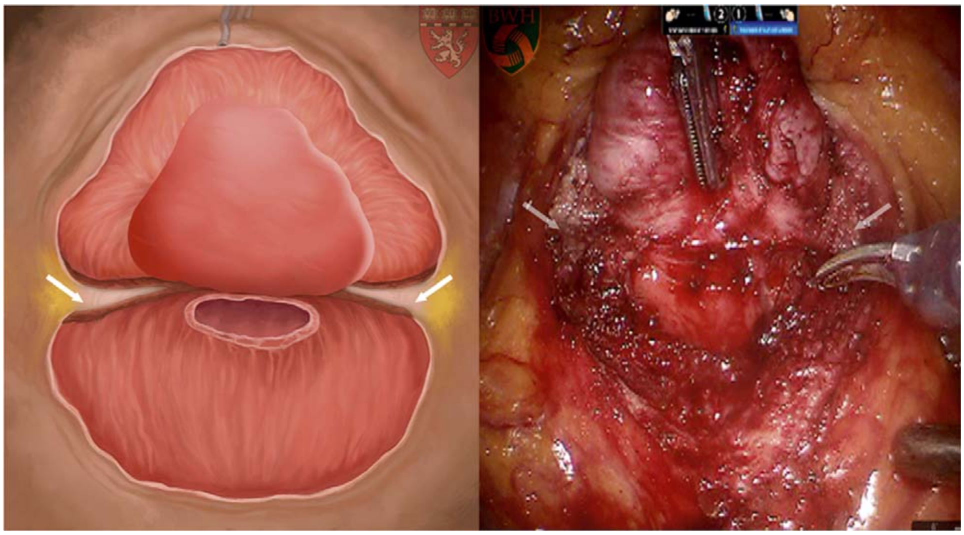

Fig. 2 – Prior to bladder entry, bladder attachments are dissected off of the prostate until reaching the prostatovesical junction (arrows). Releasing these attachments posterolaterally until encountering the lateral pedicle fat pad minimizes subsequent tearing of the bladder neck; tearing may occur with traction to facilitate dissection. The posterior bladder neck is peeled off of the median lobe to allow grasping with the Prograsp forceps for anterocaudal retraction (right).

preservation may still be accomplished by dissecting distal to the cystotomy to release the bladder. Distal anterior cystotomies are not repaired separately but are incorporated into the anastomosis with suturing that starts proximal to the cystotomy and ends through the urethra. Moreover, releasing the anterolateral bladder away from the prostate prior to division of the anterior bladder neck minimizes tearing of the cystotomy, which may occur with subsequent dissection traction (Fig. 2). Identification and dissection of the lateral prostatovesical junction is facilitated by blunt dissection using concurrent spreading with the Maryland dissector and a ''breast stroke'' maneuver with the scissors. This allows at least 180° anterior circumferential bladder neck dissection and clearer median lobe identification prior to sharp division of the anterior bladder neck [15].

After transverse incision of the anterior bladder neck, the catheter balloon is deflated and pulled back to reveal the posterior bladder neck mucosa. The posterior mucosa is divided with monopolar cautery, and the mucosa is peeled away from the median lobe using a combination of blunt and sharp dissection, anatomically preserving the bladder neck. We do not use intravenous indigo carmine or methylene blue to identify the ureteral orifices [20]. With a relatively preserved bladder neck, the ureteral orifices remain safely out of view and proximal to the bladder neck. We take approximately a 1-cm bite on the bladder when suturing the anastomosis to avoid injury to the ureteral orifice [19]. Moreover, for wide bladder necks, we perform anterior bladder neck reconstruction to avoid ureteral injury [15]. With this technique, we have experienced one ureteral injury in a duplicated system. After dissecting the posterior bladder neck away from the median lobe to allow fourth-arm Prograsp anterocaudal retraction on the median lobe and anterocephalad assistant laparoscopic grasper retraction on the posterior bladder neck, the anatomic plane between the posterior median lobe and prostate base and the posterior bladder is tented up and more clearly identified (Fig. 3).

After division of the posterior bladder mucosa, a potential pitfall is inadvertent cystotomy, or ''button-holing,'' of the posterior bladder neck, which occurs with a dissection plane proximal to the anatomic posterior

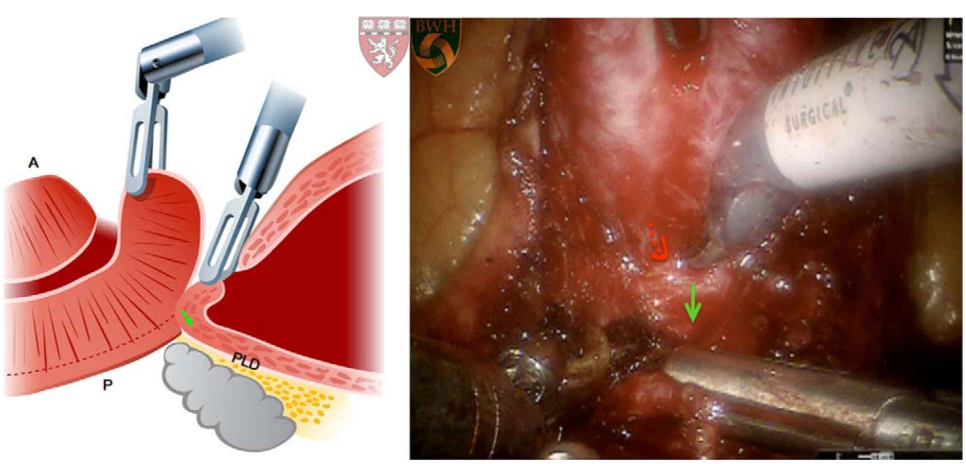

Fig. 3 – Anterocaudal fourth-arm Prograsp tension is applied to the median lobe, while the assistant applies anterocephalad tension to the posterior bladder neck to identify the anatomic dissection plane. The assistant intermittently releases the posterior bladder neck to allow the surgeon to index the bladder mucosa contour to avoid dissecting too proximally and ''button-holing.'' Conversely, one must not continue to follow the curve of the median lobe (dotted red line/arrow), as the anatomic posterior plane lies in a posterocephalad direction (green arrow) and the posterior (P) versus anterior (A) prostate distance is always greater. The posterior longitudinal detrusor (PLD) fibers should be encountered anterior to the adipose tissue and vas/seminal vesicles.

prostatovesical junction. Identification of circular posterior bladder neck fibers aids in identifying the proper plane. In addition, visualizing the posterior bladder mucosa contour as a reference point (during release of assistant laparoscopic posterior bladder neck counter-traction) and adjusting the dissection plane accordingly minimize the risk of cystotomy. Conversely, dissecting along the median lobe contour as it curves distal to the prostatovesical junction (between the transition and peripheral zones, as with simple prostatectomy) will result in incomplete prostate resection, and the vas and seminal vesicles will not be encountered. Also, the anatomic plane of the posterior prostatovesical junction courses in a posterocephalad direction (accentuated in the Trendelenburg position), as the distance from prostate apex to the base is always longer along the posterior versus anterior prostate surface (Fig. 3).

Nerve sparing may be challenging with larger prostates, because there is less space in the pelvis. First, the mass effect limits the posterior apical dissection of the prostate away from the Denonvilliers' fascia when defining the posterior prostate contour [16] and therefore requires greater prostate rotation and posterior circumferential apical dissection at a later step [17]. Second, the neurovascular bundles (NVB) are often displaced more posteriorly. This, along with the mass effect, contributes to greater difficulty in visualizing the NVB around a larger prostate, particularly at the apex, and antegrade nerve sparing may need to be performed asynchronously. In other words, we cease antegrade nerve sparing bilaterally at the midprostate to avoid poor exposure at the apex; exposure improves after division of the detrusor apron and DVC. This allows improved apical nerve sparing without excessive medial traction while rotating the prostate to offset poor exposure secondary to prostate mass effect [17].

2.3. Outcomes

Prostate size was determined by weighing the specimen with the seminal vesicles prior to inking, within 2 h of removal. Tumor volume was measured as the maximum diameter in centimeters. Postoperative urine leak was defined as elevated drain creatinine or cystogram extravasation, and cystography was performed for men with large bladder necks and clinical signs of urine leak (high drain output, ileus, elevated drain creatinine). Urinary and sexual function outcomes were assessed preoperatively and at 5, 12, and 24 mo postoperatively using the Expanded Prostate Cancer Index Composite (EPIC). The EPIC urinary and sexual function scale is scored continuously from 0 to 100, with higher scores indicating better outcomes [21].

2.4. Statistical analysis

All clinical and quality of life (QoL) outcomes were prospectively collected by research personnel uninvolved with clinical care and entered into Microsoft Office Access (Microsoft, Redmond, WA, USA). The response rate at 5, 12, and 24 mo was 75%, 82%, and 57%, with 12%, 21%, and 41% of subjects reached by telephone rather than office visits at the respective periods. There were no differences between responder and nonresponder demographics, tumor characteristics, or baseline EPIC scores. Statistical analyses were performed using SAS v.9.2 (SAS Institute, Cary, NC, USA). Wilcoxon rank sum, χ^2, Fisher exact, and student t tests were used for univariate and bivariate analyses. Postoperative QoL outcomes were nonparametric; therefore, median values were assessed. Linear regression models, with exclusion of covariates with univariate p values $\geq$0.2, were constructed to assess the effects of BPH characteristics on operative time, estimated blood loss (EBL), PSM, and urinary and sexual function.

3. Results

3.1. Study population characteristics

Baseline characteristics are categorized by quartiles of prostate size in Table 1. Men with larger prostates were more likely to be white (p = 0.008), older (p < 0.001), have a

Table 1 – Demographic characteristics by prostate size

	Quartile 1 24–41 g n = 224	Quartile 2 42–50 g n = 241	Quartile 3 51–62 g n = 244	Quartile 4 63–218 g n = 242	p value
Age, yr, mean ± SD	56.8 ± 6.8	57.1 ± 6.7	59.5 ± 6.5	61.4 ± 5.6	< 0.001
BMI, kg/m^2, mean ± SD	27.6 ± 4.2	28.6 ± 4.7	28.3 ± 4.1	30.2 ± 5.1	<0.001
Preoperative PSA, ng/ml, mean ± SD	5.1 ± 3.4	5.4 ± 3.0	5.2 ± 2.6	6.6 ± 3.5	<0.001
Baseline urinary function score, mean ± SD	96.8 ± 9.7	96.5 ± 11.2	96.4 ± 10.4	93.6 ± 12.0	0.002
Baseline sexual function score, mean ± SD	77.5 ± 27.2	76.3 ± 27.3	73.4 ± 28.8	67.1 ± 29.5	<0.001
Race, No. (%)					
White	201 (89.7)	224 (92.9)	231 (94.7)	229 (94.6)	0.008
Black	11 (4.9)	12 (5.0)	6 (2.5)	11 (4.6)	–
Other	12 (5.4)	5 (2.1)	7 (2.9)	2 (0.8)	–
Clinical stage, No. (%)					
T1c	203 (90.6)	218 (90.5)	226 (92.6)	227 (93.8)	0.044
T2a	14 (6.3)	19 (7.9)	14 (5.7)	13 (5.4)	–
T2b	3 (1.3)	2 (0.8)	2 (0.8)	2 (0.8)	–
T2c	4 (1.8)	2 (0.8)	2 (0.8)	0 (0)	–
Biopsy Gleason score, No. (%)					
3 + 2	0 (0)	1 (0.4)	0 (0)	3 (1.2)	0.322
3 + 3	127 (56.7)	142 (58.9)	143 (58.6)	144 (59.5)	–
3 + 4	61 (27.2)	62 (25.7)	75 (30.7)	58 (24.0)	–
4 + 3	26 (11.6)	24 (10.0)	15 (6.2)	26 (10.7)	–
4 + 4	7 (3.1)	9 (3.7)	9 (3.7)	10 (4.1)	–
3 + 5	1 (0.5)	1 (0.4)	0 (0)	1 (0.4)	–
4 + 5	1 (0.5)	1 (0.4)	2 (0.8)	0 (0)	–
5 + 4	1 (0.5)	1 (0.4)	0 (0)	0 (0)	–

SD = standard deviation; PSA = prostate-specific antigen.

Table 2 – Perioperative and pathologic outcomes by prostate size

	Quartile 1 24–41 g n = 221	Quartile 2 42–50 g n = 240	Quartile 3 51–62 g n = 240	Quartile 4 63–218 g n = 239	p value
Perioperative outcomes					
EBL, ml, mean ± SD	176.5 ± 89.0	194.1 ± 97.3	195.3 ± 80.6	213.5 ± 103.4	<0.001
Hematocrit change, mean ± SD*	9.0 ± 3.5	8.6 ± 3.6	8.8 ± 3.5	9.2 ± 3.6	0.514
Operative time, min, mean ± SD	149.1 ± 39.3	153.3 ± 40.5	158.0 ± 40.1	164.2 ± 48.4	0.002
Length of stay, d, mean ± SD	1.2 ± 1.0	1.2 ± 0.7	1.1 ± 0.5	1.3 ± 1.0	0.020
Catheterization time, d, mean ± SD	7.6 ± 3.2	7.7 ± 2.8	7.6 ± 2.3	8.5 ± 4.3	0.021
Blood transfusion, No. (%)	1 (0.5)	0 (0)	0 (0)	4 (1.7)	0.037
Nerve-sparing approach, No. (%)					
Non–nerve sparing	12 (5.4)	16 (6.6)	16 (6.6)	29 (12.0)	0.065
Unilateral nerve sparing	24 (10.7)	36 (15.0)	34 (13.9)	25 (10.3)	–
Bilateral nerve sparing	188 (83.9)	189 (78.4)	194 (79.5)	188 (77.7)	–
Bladder neck sparing	165 (73.7)	166 (68.9)	169 (69.3)	173 (71.5)	0.648
Perioperative complications, No. (%)					
Anastomotic structure	1 (0.5)	3 (1.2)	1 (0.4)	2 (0.8)	0.684
Rectal injury	0 (0)	0 (0)	1 (0.4)	2 (0.8)	0.314
Inadvertent cystotomy	2 (0.9)	1 (0.4)	2 (0.8)	2 (0.8)	0.926
Urine leak**	7 (3.2)	8 (3.5)	4 (1.7)	13 (5.8)	0.130
Ureteral injury	0 (0)	0 (0)	1 (0.4)	0 (0)	0.399
UTI	0 (0)	4 (1.7)	2 (0.8)	1 (0.4)	0.184
Pathologic outcomes, mean ± SD					
Gland volume, g	36.3 ± 4.0	45.6 ± 2.3	54.8 ± 3.4	81.2 ± 22.6	<0.001
Tumor volume, cm	1.4 ± 0.6	1.4 ± 0.6	1.3 ± 0.7	1.3 ± 0.7	0.056
Pathologic stage, No. (%)					
T0	1 (0.5)	3 (1.2)	0 (0)	3 (1.2)	0.111
T2a	18 (8.1)	32 (13.3)	32 (13.1)	33 (13.6)	–
T2b	7 (3.1)	2 (0.8)	4 (1.6)	5 (2.1)	–
T2c	166 (74.4)	159 (66.0)	172 (70.5)	169 (69.8)	–
T3a	24 (10.8)	31 (12.9)	26 (10.7)	25 (10.3)	–
T3b	7 (3.1)	14 (5.8)	10 (4.1)	7 (2.9)	–
Gleason grade, No. (%)					
3 + 2	0 (0)	0 (0)	0 (0)	4 (1.7)	0.135
3 + 3	79 (35.3)	86 (35.7)	101 (41.4)	98 (40.5)	–
3 + 4	96 (42.9)	94 (39.0)	97 (39.8)	85 (35.1)	–
4 + 3	40 (17.9)	43 (17.8)	31 (12.7)	40 (16.5)	–
4 + 4	5 (2.2)	10 (4.2)	8 (3.3)	5 (2.1)	–
3 + 5	1 (0.5)	1 (0.4)	1 (0.4)	0 (0)	–
5 + 3	0 (0)	1 (0.4)	0 (0)	0 (0)	–
4 + 5	1 (0.5)	6 (2.5)	6 (2.5)	7 (2.9)	–
5 + 4	1 (0.5)	0 (0)	0 (0)	0 (0)	–
Positive margin status, No. (%)					
Total	32 (14.4)	37 (15.4)	33 (13.6)	25 (10.3)	0.157
Base	1 (0.5)	6 (2.5)	6 (2.5)	1 (0.4)	0.915

SD = standard deviation; EBL = estimated blood loss; UTI = urinary tract infection.
* Difference between preoperative and recovery room hematocrit.
** Nine patients were excluded from analysis of urine leak because barbed polyglyconate suture material was used.

higher body mass index (BMI; $p < 0.001$) and preoperative PSA ($p < 0.001$), to present with cT1 disease ($p = 0.044$), and have worse baseline urinary ($p = 0.002$) and sexual ($p < 0.001$) function. The mean interval between prior BPH intervention and RALP was 3.9 yr.

3.2. *Outcomes*

In unadjusted analyses, larger prostate size ($p = 0.002$), prior BPH intervention ($p = 0.004$), and the presence of a median lobe ($p = 0.004$) prolonged operative times (Tables 2 and 3). Lymph node dissection was performed in 83 (9.6%) RALP cases; however, it did not significantly lengthen operative time in unadjusted (145.0 vs 140.5 min; $p = 0.199$) or adjusted ($p = 0.925$) analyses. Larger prostates ($p < 0.001$) and median lobes ($p = 0.002$) were also associated with greater blood loss, and larger prostates were also associated with more transfusions ($p = 0.037$). In addition, larger prostates were associated with longer hospital stay ($p = 0.020$) and longer catheterization ($p = 0.021$). Although there were no differences in tumor characteristics by prostate size, men with prior BPH intervention were more likely to have prostate base PSM values (5.1% vs 1.1%; $p = 0.018$), while overall PSM values remained similar. Median lobe and prior BPH surgical intervention did not affect recovery of urinary or sexual function. Although

Table 3 – Perioperative and pathologic outcomes by benign prostatic hyperplasia characteristics

	Prior BPH intervention			Median lobe		
	Yes n = 59	No n = 892	p value	Yes n = 42	No n = 909	p value
Perioperative outcomes						
EBL, ml, mean ± SD	209.2 ± 94.1	194.4 ± 93.8	0.181	236.4 ± 99.9	193.3 ± 93.1	0.002
Hematocrit change, mean ± SD*	9.4 ± 3.0	8.9 ± 3.6	0.122	9.4 ± 4.4	8.9 ± 3.5	0.642
Operative time, min, mean ± SD	170.2 ± 45.7	155.4 ± 42.2	0.004	185.8 ± 65.8	155.0 ± 40.8	0.004
Length of catheterization, d, mean ± SD	7.6 ± 1.9	7.9 ± 3.3	0.699	8.7 ± 3.7	7.8 ± 3.2	0.107
Blood transfusion, No. (%)	0 (0)	5 (0.6)	0.726	0 (0)	5 (0.6)	0.798
Bladder neck sparing, No. (%)	20 (33.9)	653 (73.2)	<0.001	25 (59.5)	648 (71.3)	0.101
Urine leak, No. (%)	0 (0)	31 (3.7)	0.138	2 (5.0)	29 (3.4)	0.574
Perioperative complications						
Anastomotic stricture, No. (%)	1 (1.7)	6 (0.7)	0.362	0 (0)	7 (0.8)	0.782
Rectal injury, No. (%)	0 (0)	3 (0.3)	0.825	1 (2.4)	2 (0.2)	0.127
Inadvertent cystotomy, No. (%)	1 (1.7)	6 (0.7)	0.362	1 (2.4)	6 (0.7)	0.272
Urine leak, No. (%)**	0 (0)	32 (3.8)	0.258	2 (5.0)	30 (3.5)	0.648
Ureteral injury, No. (%)	0 (0)	1 (0.1)	0.938	0 (0)	1 (0.1)	0.956
UTI, No. (%)	0 (0)	7 (0.8)	0.638	0 (0)	7 (0.8)	0.728
Pathologic outcomes						
Gland volume, g, mean ± SD	59.0 ± 29.7	54.6 ± 19.7	0.697	73.0 ± 34.8	54.0 ± 19.1	<0.001
Tumor volume, cm, mean ± SD	1.1 ± 0.6	1.3 ± 0.7	0.005	1.1 ± 0.6	1.3 ± 0.7	0.072
Positive margin status, No. (%)						
Base	3 (5.1)	11 (1.2)	0.018	0 (0)	14 (1.5)	0.418
Overall	9 (15.3)	118 (13.3)	0.663	4 (9.5)	123 (13.6)	0.453

BPH = benign prostatic hyperplasia; SD = standard deviation; EBL = estimated blood loss; UTI = urinary tract infection.
* Difference between preoperative and recovery room hematocrit.
** Nine patients were excluded from analysis of urine leak because barbed polyglyconate suture material was used.

Table 4 – Unadjusted functional outcomes by prostate size

	Urinary function, median (IQR)				
	Quartile 1	Quartile 2	Quartile 3	Quartile 4	p value*
5 mo	66.7 (44.7–91.7)	64.0 (44.7–89.0)	64.0 (33.3–89.0)	61.3 (41.7–89.0)	0.481
12 mo	89.0 (72.3–100)	89.0 (64.0–91.7)	82.0 (58.3–100.0)	80.7 (69.7–100)	0.581
24 mo	100 (86.2–100)	89.0 (64.0–100)	91.7 (65.3–100)	89.0 (66.7–100)	0.128
	Sexual function, median (IQR)				
	Quartile 1	Quartile 2	Quartile 3	Quartile 4	p value*
5 mo	13.3 (0–33.4)	10.0 (0–26.6)	10.0 (0–26.6)	5.0 (0–20.0)	0.012
12 mo	31.6 (15.8–58.4)	31.6 (15.0–60.0)	31.6 (12.5–60.0)	23.4 (5.0–53.4)	0.216
24 mo	61.7 (31.6–85.0)	51.6 (25.0–80.0)	39.6 (20.0–75.9)	38.4 (11.6–80.0)	0.145

IQR = interquartile range.
* Kruskal-Wallis test.

prostate size did not affect urinary function, men with larger prostates experienced worse 5-mo sexual function (p = 0.012), without differences in late sexual function (Table 4).

In adjusted analyses (Table 5), median lobes, previous BPH and abdominal surgery, greater prostate size, and BMI were associated with longer operative times (all $p < 0.05$). Although median lobe (p = 0.006), previous abdominal surgery (p = 0.034), and higher BMI ($p < 0.001$) increased EBL, prostate size did not. We were unable to perform multivariate analyses for base PSM because of few events (n = 14), but prostate size did not affect overall PSM.

After adjusting for preoperative characteristics, prostate size as a continuous variable did not affect urinary or sexual function (Tables 6 and 7). Older age ($p < 0.05$) and non–nerve sparing ($p < 0.001$) were associated with worse 5- and 12-mo urinary function, and older age was associated with worse sexual function recovery at all time points ($p < 0.05$). In addition, non–nerve sparing adversely affected 12- and 24-mo sexual function ($p < 0.05$). The DVC control technique affected urinary function recovery: DVC-SSL and stapling versus nonselective DVC suture ligation was associated with better 5-mo urinary function ($p < 0.05$). Finally, bladder neck preservation did not improve urinary function. However, comparison of unadjusted bladder neck preservation versus nonpreservation of median urinary function was improved at 5 mo (65.0 vs 61.1; p = 0.011) but not 12 mo (89.0 vs 80.7; p = 0.227) or 24 mo (91.7 vs 91.7; p = 0.312).

Table 5 – Multivariate model of estimated blood loss and operative time

	EBL			Operative time		
Covariate	Parameter estimate	Standard error	*p* value	Parameter estimate	Standard error	*p* value
BMI	3.73	0.66	<0.001	0.98	0.30	0.001
Previous abdominal surgery	15.55	7.32	0.034	7.61	3.29	0.021
Non-nerve sparing vs bilateral nerve sparing	3.90	11.78	0.741	−0.80	5.26	0.879
Unilateral vs bilateral nerve sparing	11.60	9.28	0.211	−0.74	4.20	0.860
Lymph node vs no lymph node dissection	−6.72	11.26	0.551	−0.48	5.12	0.925
Gland volume	0.23	0.15	0.125	0.25	0.07	<0.001
Previous BPH intervention	14.92	12.63	0.238	13.92	5.66	0.014
Median lobe	40.53	14.79	0.006	26.43	6.85	<0.001

EBL = estimated blood loss; BMI = body mass index; BPH = benign prostatic hyperplasia.

Table 6 – Multivariate model of urinary function recovery

	5 mo			12 mo			24 mo		
Covariate	Parameter estimate	Standard error	*p* value	Parameter estimate	Standard error	*p* value	Parameter estimate	Standard error	*p* value
Gland volume	−0.05	0.05	0.402	0.00	0.04	0.988	−0.02	0.06	0.769
Age	−0.70	0.17	<0.001	−0.28	0.13	0.036	−0.29	0.21	0.164
BMI	−0.46	0.24	0.055	−0.07	0.20	0.716	0.27	0.29	0.354
Baseline urinary function	0.37	0.11	0.001	0.35	0.08	<0.001	0.36	0.12	0.003
Nonsparing vs bladder neck sparing	−2.39	3.19	0.455	−2.37	2.39	0.321	−0.42	3.08	0.891
Selective* vs nonselective DVC suture ligation	17.61	2.47	<0.001	0.56	2.60	0.831	–	–	–
DVC stapling vs nonselective DVC ligation	9.93	3.44	<0.001	4.03	2.44	0.100	8.98	3.10	0.004
Non–nerve sparing vs bilateral nerve sparing	−15.60	4.30	<0.001	−11.78	3.26	<0.001	−6.56	4.74	0.168
Unilateral vs bilateral nerve sparing	−0.59	3.12	0.849	−7.32	2.41	0.003	−8.24	3.72	0.028

BMI = body mass index; DVC = dorsal vein complex.
* Technical modification occurred in May 2009: insufficient follow-up for 24-mo outcomes.

Table 7 – Multivariate model of sexual function recovery

	5 mo			12 mo			24 mo		
Covariate	Parameter estimate	Standard error	*p* value	Parameter estimate	Standard error	*p* value	Parameter estimate	Standard error	*p* value
Gland volume	−0.07	0.04	0.089	0.01	0.06	0.872	−0.08	0.08	0.293
Age	−0.31	0.14	0.025	−0.50	0.19	0.007	−0.74	0.30	0.015
BMI	−0.09	0.19	0.635	−0.30	0.26	0.239	−0.64	0.41	0.119
Baseline sexual function	0.15	0.03	<0.001	0.14	0.04	0.001	0.07	0.07	0.327
Non–nerve sparing vs bilateral nerve sparing	−5.15	3.49	0.141	−12.56	4.35	0.004	−23.38	6.65	0.001
Unilateral vs bilateral nerve sparing	−8.56	2.50	0.001	−15.48	3.20	<0.001	−21.16	5.29	<0.001

BMI = body mass index.

4. Discussion

Estimates of the RALP learning curve range from 150 to 600 cases [13,14], and neophytes may preoperatively perform cystoscopy or repeat prostate ultrasounds to herald BPH and/or median lobes [22]. Surgeons dependent on tactile sensation to identify the prostatovesical junction during open RP (ORP) must adjust to laparoscopic visual cues, and bladder neck dissection is a challenging RALP step [15]. We describe anatomic landmarks and reproducible surgical technique to overcome BPH median/lateral lobes, prior BPH invention, and prostate mass effect during nerve-sparing procedures. Moreover, we present associated outcomes by prostate size and BPH characteristics.

Our study has several important findings. First, larger prostate size, median lobes, and prior BPH intervention prolonged operative times. Similarly, Chan et al reported RALP operative times of 234 versus 205 min when dichotomizing size at 75 g [4], and Skolarus et al reported RALP operative times of 250 versus 232 min for prostates >100 g versus < 50 g [6]. When comparing RALP with and without median lobes, Meeks noted longer operative times of

349 versus 280 min [8]. Only Zorn et al reported no difference in RALP operative times for larger prostates [5]. Given longer operative times with greater prostate size, surgeons early in the learning curve must ensure that patients are well padded and positioned to tolerate longer operative times in Trendelenburg.

Second, median lobes were independently associated with higher EBL in adjusted analyses, while prostate size and prior BPH intervention were not. Similarly, Zorn et al found that prostate size did not affect RALP EBL [5], and Meeks et al demonstrated increased EBL (464 vs 380 ml) with median lobes [8]. Conversely, Link et al demonstrated higher EBL (250 vs 200 ml) when dichotomizing size at 70 g [7], and Chan et al demonstrated higher EBL (152 vs 139 ml) when dichotomizing size at 75 g [4]. Although others attribute greater EBL to larger prostate size, our EBL and transfusion differences were not clinically significant, with one versus four transfusions for the smallest versus largest prostates by quartiles. Moreover, we used multivariate modeling with prostate size as a continuous variable, and this may contribute to differences when comparing outcomes.

Third, prior BPH interventions increased the prostate base PSM. Hampton et al demonstrated more overall RALP PSM—35.3% versus 17.6% with prior versus no BPH intervention [10]—and an LRP series demonstrated an overall PSM of 21.8% versus 12.6% with prior versus no prior TURP [11]. Similarly, Colombo et al described technical difficulties during ORP at the prostate base, with prior TURP attributed to a fibrotic inflammatory reaction, noting an inability to remove the prostate en bloc in 28% of these cases [23]. Although prior BPH intervention increased base PSM, overall PSM numbers were unaffected by prior BPH intervention, prostate size, or median lobes. This finding contrasts studies demonstrating fewer PSM with larger prostates. We assessed prostate size by quartiles and as a continuous variable, but Link et al reported fewer PSM during RALP (21.2% vs 34.8%) when dichotomizing at 70 g [7]. Similarly, Chan et al reported fewer PSM in larger prostates (9.9% vs 19.0%) when dichotomizing at 75 g [4]. Finally, Zorn et al reported an inverse relationship between prostate size and PSM for pT2 but not pT3 disease [5]. Regardless, larger prostate size (dichotomized at 75 g) is associated with more favorable biochemical recurrence–free survival [24,25].

Fourth, after adjusting for age and baseline QoL, prostate size did not affect recovery of urinary and sexual function. Similarly, Foley et al dichotomized size at 75 g for ORP and reported that prostate size did not affect continence (no pads) or potency (erection sufficient for intercourse) [25]. Levinson et al dichotomized LRP prostate size at 70 g and reported similar EPIC urinary function recovery [26]. In contrast, Hollenbeck et al dichotomized size at 59 g in a multisurgeon series and demonstrated that larger prostate size adversely affected ORP EPIC sexual function scores (29 vs 39) [27]. However, heterogeneous surgical technique by multiple surgeons may contribute to variation in outcomes when compared to our single-surgeon series. Moreover, we describe nerve-sparing technical modifications for large prostates that affected our outcomes.

Although some surgeons may prefer to reconstruct the bladder neck prior to anastomosis, particularly with median lobes [6,28,29], we prefer bladder neck preservation to obviate the need for reconstruction, decrease the risk of urine leaks, and potentially shorten catheterization times. Although we previously demonstrated improved urinary function with bladder neck preservation [15], we did not duplicate this finding when including prostate size, apical dissection, and nerve-sparing technique in the multivariate model. This may result from confounding of bladder neck preservation with the additional covariates and the inability to differentiate synchronous technical modifications that occurred with tremendous overlap. For instance, DVC-SSL and bladder neck preservation were performed concurrently in 96% of RALP cases, and unadjusted analyses revealed improved early urinary function with bladder neck preservation.

Our study must be interpreted in the context of the study design. First, all RALP cases were performed by a fellowship-trained surgeon, and prostatectomy outcomes are inherently technique specific. However, the strength of video is the demonstration of technique rather that the use of terms such as *nerve sparing* or *bladder neck preservation,* which may have significant technical variation as well as different meaning and application to other surgeons. Second, this was not a randomized control trial, which is difficult to conduct, as surgeons are biased toward certain techniques with more experience. However, our goal is to describe reproducible techniques to help others overcome challenging BPH characteristics and improve outcomes. Moreover, we used third-party data collection of self-reported QoL outcomes from a validated instrument. Third, we incurred loss to follow-up despite repeated attempts to contact nonresponders. This loss is inevitable with travel to referral centers, but responders and nonresponders did not differ in baseline characteristics.

5. Conclusions

Large prostate size and BPH characteristics pose challenges that increase operative times and EBL during RALP but do not affect recovery of urinary or sexual function. Technical modifications to overcome median lobe hypertrophy, prior BPH surgeries, and nerve sparing improve both perioperative and long-term outcomes.

Author contributions: Jim C. Hu had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Hu.
Acquisition of data: Huang, Kowalczyk, Yu, Plaster, Amarasekara, Ulmer, Lei, Hu.
Analysis and interpretation of data: Huang, Kowalczyk, Hevelone, Lipsitz, Yu, Williams, Hu.
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Appendix A. Supplementary data

The Surgery in Motion video accompanying this article can be found in the online version at doi:10.1016/j.eururo.2011.01.033 and via www.europeanurology.com.

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