JOURNAL OF ENDOUROLOGY
Volume 22, Number 8, August 2008
© Mary Ann Liebert, Inc.
Pp. 1565–1567
DOI: 10.1089/end.2008.0109

Tricks of the Trade

Landmarks for Consistent Nerve Sparing during Robotic-Assisted Laparoscopic Radical Prostatectomy*

Alexander Berry, M.D., M.B.A., Fernando Korkes, M.D., and Jim C. Hu, M.D., M.P.H.

Problem

ATHERMAL NERVE-SPARING IN SELECTED MEN improves postoperative potency.[1,2] Consistently identifying and dissecting in either the interfascial or intrafascial plane, however, may be challenging. A number of techniques to perform nerve-sparing without cautery/harmonic energy have been previously described. We outline an approach to spare the neurovascular bundle (NVB) that emphasizes definition of posteromedial and anterolateral prostatic contours with landmarks to facilitate dissection of the interfascial plane, separating the two leaves of lateral pelvic fascia.[3] In general, this approach is extended for intrafascial dissection only for men with low-volume, low-risk disease characteristics.

Technique

There are three important steps: (1) identification and dissection of the posterior plane between the prostatic and Denonvilliers' fascia to define the posterior prostatic contour; (2) entry into the interfascial plane at the midprostate, facilitating fascial separation that defines the anterolateral prostatic contour; (3) division of the prostatic pedicle and NVB release in an antegrade fashion.

After entry into the space of Retzius (with an extra or transperitoneal approach), the bladder neck is divided and the seminal vesicles are dissected free. The endopelvic fascia is not entered at this point. The seminal vesicles are then elevated out of the way by the fourth arm, and the plane between prostatic and Denonvilliers' fascia is sharply entered in the midline. The correct dissection plane is identified by a layer of glistening Denonvilliers' fascia inferiorly. If prerectal fat is seen, the plane of dissection is deep and is brought closer to the prostate. The dissection is continued laterally and distally until the medial border of the NVB is appreciated. This ensures adequate thinning of the vascular pedicle facilitating subsequent clip placement, aids in lateralization of the NVB, and defines the posterior prostatic contour (Fig. 1).

The lateral pelvic fascia interfascial plane is exposed anteriorly via a "prostatic rub" entering the fusion point of endopelvic and lateral pelvic fascia at the midprostate level. The levator fascia, the lateral leaf of the lateral pelvic fascia, is swept from the anterolateral prostatic contour along a natural cleavage plane. The dissection is continued until nerve plexus components are encountered running lateral on the medial surface of the levator fascia. These are swept from the prostate and remain intact on the levator fascia, underlying the levator muscle (Fig. 2). If levator muscle fibers are seen, the plane of dissection is too lateral and is brought medially. If intrafascial dissection is performed, the prostatic fascia, the medial leaf of lateral pelvic fascia, may be entered sharply and elevated in similar fashion as described by Menon and colleagues.[1] The dissection is continued retrograde until the distal extent of the prostatic pedicle is encountered.

The prostatic pedicles are placed on 45-degree supramedial tension. The posteromedial and anterolateral contours of the prostate can now be easily appreciated and the prostatic pedicle clipped and divided medial to the NVB, completing the circumferential dissection along the prostatic contour (Fig. 3). The NVB can now continue to be released in an antegrade, athermal fashion in either the interfascial or intrafascial plane as desired.

Conclusion

Using self-reported, validated, quality-of-life instruments, we have observed earlier and significantly improved sexual function with the described technique. Care must be taken when modifying NVB-sparing techniques, as margin rate positivity may offset improved recovery of sexual function.

Division of Urology, Brigham and Women's Hospital, Boston, MA 02115.

*A video demonstrating the technique described here is available online at www.liebertpub.com/end.

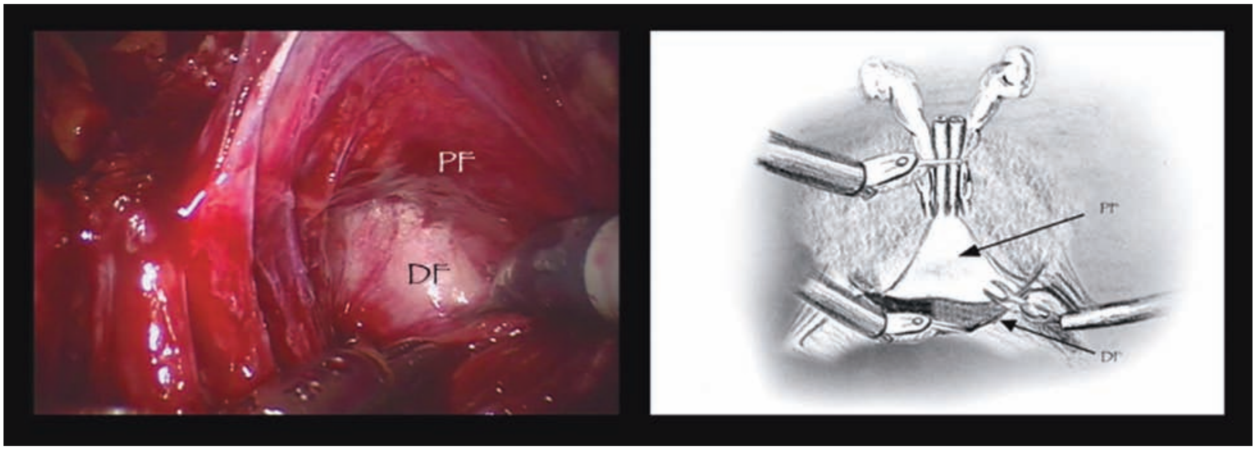


FIG. 1. The dissection plane between Denonvilliers' (DF) and the prostatic fascia (PF) is developed, defining the posterior prostatic contour.

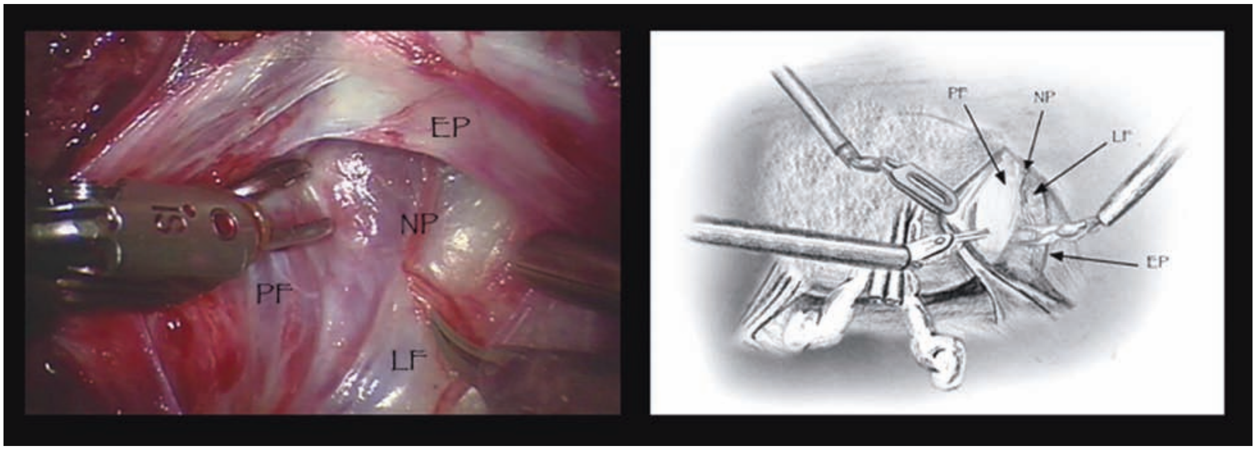


FIG. 2. Separation of lateral pelvic fascia into prostatic fascia (PF) and levator fascia (LF) defining nerve plexus components (NP) and anterolateral prostatic contour. Endopelvic fascia (EP).

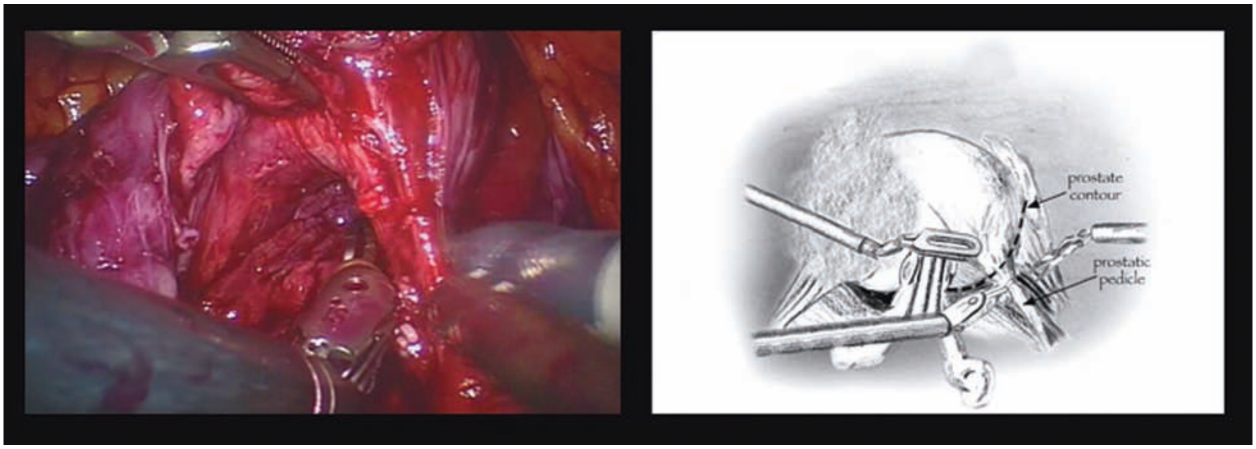


FIG. 3. Dotted line represents plane of dissection as defined by posterior and anterolateral prostatic contours.

References

1. Menon M, Shrivastava A, Kaul S, et al. Vattikuti Institute prostatectomy: contemporay technique and analysis of results. Eur Urol 2007; 51:648–658.
2. Rassweiler J, Wagner A, Moazin M, et al. Anatomic nerve-sparing laparoscopic radical prostatectomy: comparison of retrograde and antegrade techniques. Urology 2006; 68:587–591.
3. Lepor H, Gregerman M, Crosby R, et al. Precise localization of the autonomic nerves from the pelvic plexus to the corpora cavernosa: a detailed anatomical study of the adult male pelvis. J Urol 1985; 133:207–212.

Address reprint requests to:
Dr. Jim Hu
Division of Urology
Brigham and Women's Hospital
45 Francis Street, ASBII-3
Boston, MA 02115

E-mail: JHU2@partners.org

Abbreviation Used

NVB = neurovascular bundle

EUROPEAN UROLOGY 56 (2009) 972–980

available at www.sciencedirect.com
journal homepage: www.europeanurology.com

European Association of Urology

Surgery in Motion

Anatomic Bladder Neck Preservation During Robotic-Assisted Laparoscopic Radical Prostatectomy: Description of Technique and Outcomes

Marcos P. Freire[a], *Aaron C. Weinberg*[a], *Yin Lei*[a], *Jane R. Soukup*[b], *Stuart R. Lipsitz*[b], *Sandip M. Prasad*[a], *Fernando Korkes*[d], *Tiffany Lin*[a], *Jim C. Hu*[a,b,c,*]

[a] *Division of Urologic Surgery, Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA*
[b] *Center for Surgery and Public Health, Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA*
[c] *Lank Center for Genitourinary Oncology, Dana-Farber Cancer Institute, Boston, MA, USA*
[d] *Faculdade de Medicina do ABC, São Paulo, Brazil*

Article info

Article history:
Accepted September 1, 2009
Published online ahead of print on September 12, 2009

Keywords:
Radical prostatectomy
Continence
Outcomes
Robotic surgical technique

Please visit www.europeanurology.com and www.urosource.com to view the accompanying video.

Abstract

Background: Robotic-assisted laparoscopic radical prostatectomy (RALP) has been rapidly adopted despite a daunting learning curve with bladder neck dissection as a challenging step for newcomers.

Objective: To describe an anatomic, reproducible technique of bladder neck preservation (BNP) and associated perioperative and long-term outcomes.

Design, settings, and participants: From September 2005 to May 2009, data from 619 consecutive RALP were prospectively collected and compared on the basis of bladder neck dissection technique with 348 BNP and 271 standard technique (ST).

Surgical procedure: RALP with BNP.

Measurements: Tumor characteristics, perioperative complications, and postoperative urinary control were evaluated at 4, 12 and 24 months using (1) the Expanded Prostate Cancer Index (EPIC) urinary function scale scored from 0–100; and (2) continence defined as zero pads per day.

Results and limitations: Mean age for BNP versus ST was 57.1 ± 6.6 yr versus 58.9 ± 6.7 yr ($p = 0.033$), while complication rates did not vary significantly by technique. Estimated blood loss was 183.7 ± 95.8 ml versus 224.6 ± 108 ml ($p = 0.938$) in men who underwent BNP versus ST. The overall positive margin rate was 12.8%, which did not differ at the prostate base for BNP versus ST (1.4% vs. 2.2%, $p = 0.547$). Mean urinary function scores for BNP versus ST at 4, 12, and 24 mo were 64.6 versus 57.2 ($p = 0.037$), 80.6 versus 79.0 ($p = 0.495$), and 94.1 versus 86.8 ($p < 0.001$). Similarly, BNP versus ST continence rates at 4, 12, and 24 mo were 65.6% versus 26.5% ($p < 0.001$), 86.4% versus 81.4% ($p = 0.303$), and 100% versus 96.1% ($p = 0.308$).

Conclusions: BNP versus ST is associated with quicker recovery of urinary function and similar cancer control.

---

[*] Corresponding author. Brigham and Women's Hospital, 45 Francis Street, ASBII-3, Boston, MA 02115, USA. Tel. +1 617 732 6907.
E-mail address: jhu2@partners.org (J.C. Hu).

0302-2838/$ – see back matter © 2009 European Association of Urology. Published by Elsevier B.V. All rights reserved. doi:10.1016/j.eururo.2009.09.017

1. Introduction

Robotic-assisted laparoscopic radical prostatectomy (RALP) has been rapidly adopted in recent years [1], and challenging learning curves have been described [2]. Although robotic-assistance provides advantages such as greater dexterity of instrumentation and magnified three-dimensional vision, it does not provide a novice with instant laparoscopic capabilities and proficiency in terms of tissue plane recognition [3].

Advocates of open radical prostatectomy cite the ability to feel the prostate and urethral catheter balloon during bladder neck dissection as an important advantage. Conversely, the widely noted absence of palpation during RALP may contribute to this being one of the most challenging steps for those early in their learning curve [4,5]. Suboptimal bladder neck dissection yields either residual prostate tissue when dissection is performed too distally into prostate versus a gaping bladder neck that may imperil the ureters and require reconstruction when dissection is too proximal.

The purpose of our study and accompanying video is to describe technique and anatomic landmarks for consistent bladder neck preservation (BNP) during RALP with limited use of monopolar energy, and to evaluate outcomes compared to a standard technique (ST) without bladder neck sparing.

2. Methods and patients

2.1. Enrollment

From September 2005 to May 2009, 619 patients with clinically localized prostate cancer underwent RALP, with 271 men undergoing ST bladder neck dissection and 348 undergoing BNP. The surgeon (JCH) logged 76 open radical prostatectomies during residency training and 397 transperitoneal RALP during fellowship training prior to enrollment of men to this consecutive, single-surgeon series.

2.2. Surgical technique

After entering the retropubic space of Retzius through either a transperitoneal or extraperitoneal approach, we performed the bladder

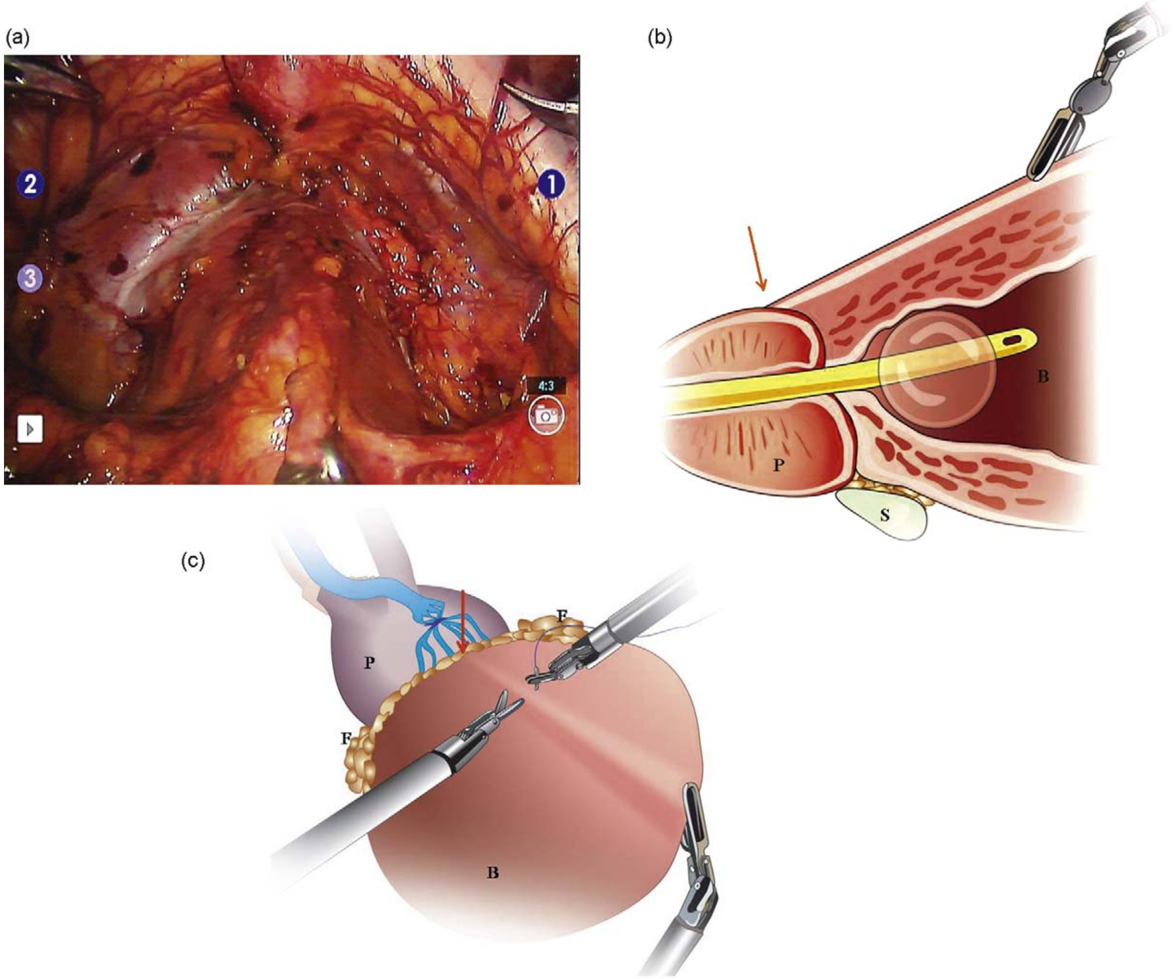


Fig. 1 – (a) Anterior aspect of the vesicoprostatic junction with application of anterocephalad fourth arm Prograsp tension; (b) diagram of the vesicoprostatic junction; (c) three-dimensional view of the vesicoprostatic junction. Red arrow represents the point at which the tented bladder fold ends and incision is made to begin bladder neck preservation technique anteriorly.
P = prostate; B = bladder; S = seminal vesicle; F = fat pad of Whitmore.

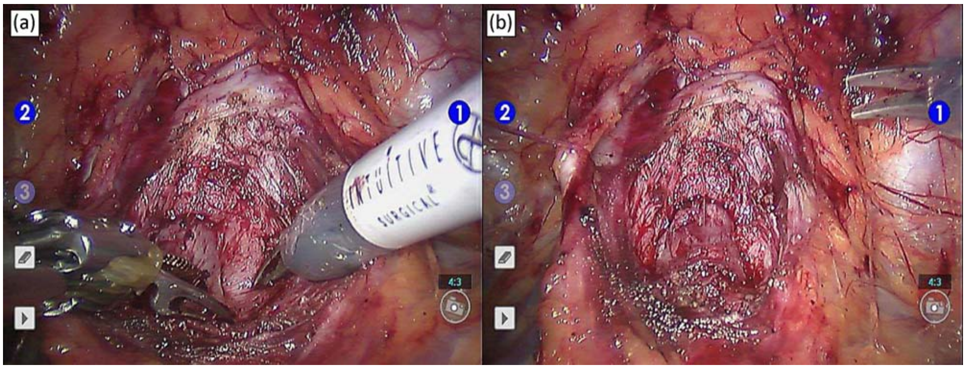


Fig. 2 – Anterior 270° circumferential dissection of funneled bladder neck.

neck dissection as the first step of a completely antegrade RALP. A Prograsp grasper, Maryland bipolar dissector, and curved monopolar scissors were inserted into the fourth arm (on the patient's left), the left, and right robotic arms, respectively. Energy settings were 25 W for both monopolar and bipolar currents.

Our initial ST bladder neck dissection was similar to that described by Menon et al [6], with greater emphasis on cold scissor dissection and selective use of bipolar energy. After completion of the anastomosis [7], an anterior tennis racket repair was performed to taper the larger bladder neck. The impetus toward BNP was to avoid a large bladder neck that was more susceptible to urine leak and prolonged catheterization. As BNP was performed with greater consistency, we did not exclude men with median lobe hypertrophy or those with high-risk features or high-volume disease from this bladder neck dissection technique.

First, mid prostatic and anterior vesical hemostatic sutures are placed (Fig. 1) with a 2-0 vicryl on a CT-1 needle (Ethicon/Johnson & Johnson, Somerville, New Jersey, USA). Next, anterocephalad tension on the bladder is created by using the fourth arm Prograsp to retract the anterior dome of the bladder (Fig. 1). This motion yields numerous advantages to the subsequent dissection: (1) tenting the anterior bladder to form a ridge that ends distally at the detrusor apron [8], serving as a landmark for the incision point of the bladder neck dissection; (2) constant tension throughout the bladder neck dissection; and (3) visualization of the contour of the urethral catheter balloon as the empty bladder caves in to form a concave contour bilaterally. The spherical contour of the Foley catheter balloon may be more difficult to appreciate in men with a greater amount of perivesical adipose tissue; however, we do not use the position of the balloon as a reference point to perform the bladder neck dissection.

Second, at the distal termination of the elevated bladder ridge, the bipolar current is used to control bleeding as sharp dissection is performed with the cold scissors. Avoiding the use of monopolar cautery lessens the amount of tissue charring, thus preserving visualization of the native anatomy that allows for identification of bladder muscle fibers, critical for defining the natural tissue plane of the vesicoprostatic junction. Once the linear fibers of the bladder neck transitioning to prostatic urethra are identified in the midline, we find the cleavage plane using a combination of sharp and blunt dissection to tease bladder muscle fibers away from the prostate, anatomically preserving a funneled bladder neck (Fig. 2).

After dissecting 270° anteriorly and circumferentially, the urethral catheter balloon is deflated and the linear anterior fibers of the bladder neck are incised as distally as possible. The assistant then withdraws the tip of the catheter from the interior bladder into view at the opened bladder neck. The assistant controls the catheter proximally and distally by holding the laparoscopic grasper with the thumb, index, and/or third finger to grasp the catheter tip while simultaneously holding the opposite end of the catheter, the catheter outlet, and balloon port, between the fourth and fifth fingers of the same hand extracorporeally (Fig. 3). This one-handed, intra and extracorporeal, assistant-surgeon manipulation of the deflated Foley catheter elevates the prostate to create tension that facilitates the posterior bladder neck dissection. This differs from the one-way traction obtained by placing a hemostat on the catheter at the meatus, which accordions the penis when the tip of the urethral catheter is elevated in the surgical field and reduces the potential elevation of the prostate and subsequent tension needed for dissection.

With traction and countertraction provided by the above-described manipulation of the Foley catheter and anterocephalad tension applied from the robotic fourth arm, the posterior bladder neck is divided starting in the midline until the posterior longitudinal fascia of the detrusor muscle [9] is encountered (Figs. 4 and 5). Dissecting laterally before identifying this landmark may result in inadvertent cystotomy or ureteral injury. Furthermore, there may be a tendency initially to dissect in a directly lateral rather than a posterolateral plane, which may lead to bleeding due to inadvertent dissection into the prostate or lateral pedicle vessels.

The dissection of bladder neck muscles inserting into the prostate base continues until adipose tissue is encountered situated at the cephalad extent of the endopelvic fascia, lateral to the bladder neck. This anatomic landmark, known as the fat pad of Whitmore (J. Montie, oral communication) was originally described during nerve-sparing radical cystectomy as the point to reach during antegrade bladder pedicle

Fig. 3 – Demonstration of the assistant grip on the laparoscopic grasper while intracorporeally holding the catheter tip to attain through and through catheter control and elevation of the prostate to create tension for the posterior bladder neck dissection.

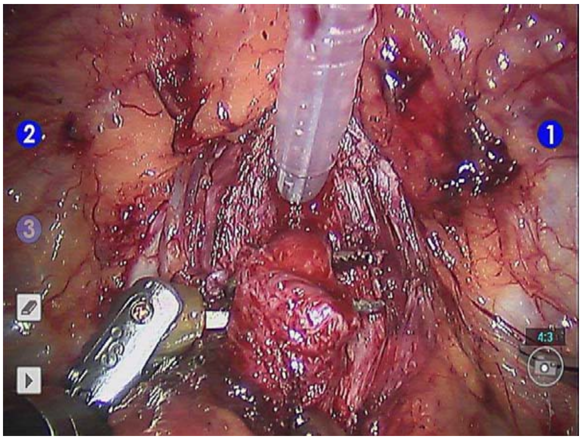


Fig. 4 – Isolation of the posterior lip of the bladder neck while Foley catheter tension is applied by the assistant to elevate the prostate.

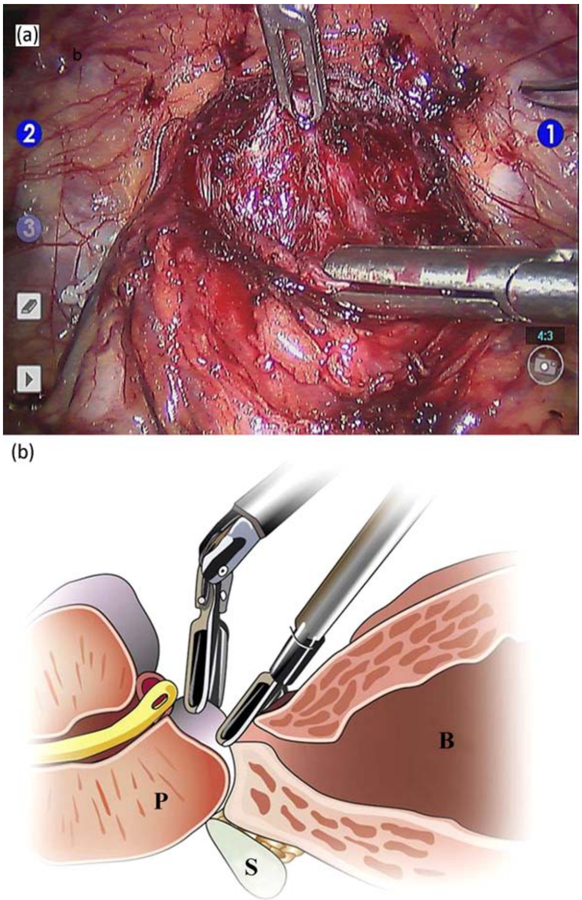


Fig. 5 – (a) The fourth arm provides upward tension on the prostate base while the assistant grasps the posterior lip of the bladder neck to provide countertension; (b) sagittal diagram.
P = prostate; B = bladder; S = seminal vesicle.

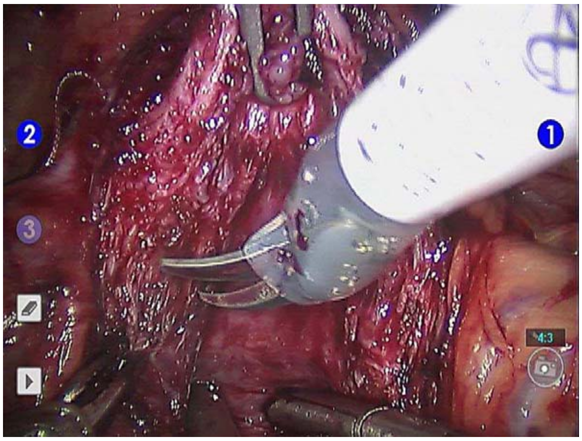


Fig. 6 – Posterolateral bladder neck dissection continues until adipose tissue (fat pad of Whitmore) is encountered.

dissection before transitioning to retrograde prostate dissection. Moreover, this defines the posterolateral bladder neck dissection boundary as the neurovascular bundle is located in close proximity to the lateral pedicle of the prostate [10] (Fig. 6).

We considered BNP to be successful when the diameter of the bladder neck was approximate to the diameter of the urethral stump, thereby not requiring reconstructive tapering prior to the vesicourethral anastomosis (Fig. 7).

Instances requiring reconstructive tapering were classified as ST. Moreover, our urethrovesical anastomotic technique [7] remained constant throughout the study period. Finally, cystography was not routinely performed postoperatively, except in men with difficult anastomosis, increased and prolonged drain output, or urinary retention at catheter removal.

2.3. Outcomes

Urinary function was prospectively assessed using the Expanded Prostate Cancer Index (EPIC) short form [11] in 447 men (224 with BNP vs. 223 with ST) during postoperative visits at 4, 12, and 24 mo. The EPIC urinary function scale is scored continuously from 0 to 100, with higher scores representing better outcomes. However, continence is commonly assessed in the urologic literature by pad use, and we also compared the EPIC item querying pad use by dichotomizing at no pads versus one pad or more per day. We defined urine leak as (1) high drain output with creatinine greater than serum levels or (2) anastomotic contrast extravasation on cystography.

2.4. Statistical analysis

All clinical data were collected and entered prospectively in an Access database (Microsoft, Redmond, WA, USA). SPSS (SPSS Inc., Chicago, IL, USA) and SAS v.9.1.2 (SAS, Cary, NC, USA) were used for the statistical analysis. The Wilcoxon rank-sum test (for non-normal variables), student *t* test (for approximately normal variables), χ^2 (for categorical variables), and Fisher exact tests (for categorical variables with a small number of events) were used to compare demographic characteristics, pathological results, and preoperative mean urinary function score across groups. An exact trend test was used to compare Gleason grade in both groups. Due to significant overlap of technique that attenuated toward predominantly BNP in later cases, we adjusted for time (learning curve) using a stratified Wilcoxon test for outcomes that may be influenced by increasing surgeon experience, as temporal learning curve effects may account for some of the observed differences in length of stay, length of catheterization, estimated blood loss, operative time, and urinary function. Similarly, differences in continence (pad use) by bladder neck dissection technique were adjusted for potential learning curve effects using a Cochran-Mantel-Haenszel test. For more complicated models in which we adjusted for learning curve effects and other

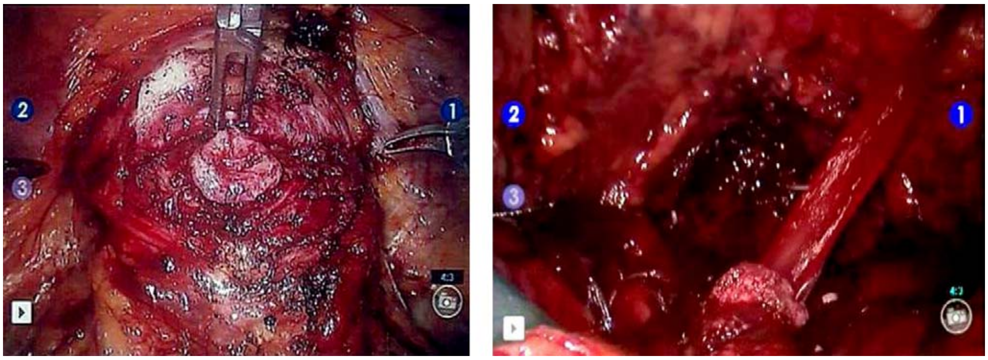


Fig. 7 – Coaptation of preserved bladder neck (left) and compression of bladder demonstrates expulsion of urine stored during robotic-assisted laparoscopic radical prostatectomy by preserved bladder neck.

potential confounders, linear regression (approximately normal outcomes), logistic regression (binary outcomes), and robust linear regression (non-normal outcomes) were used to compare outcomes for BNP versus ST.

3. Results

3.1. *Patient characteristics*

Age differed by technique with means of 57.1 ± 6.6 yr and 58.9 ± 6.7 yr ($p = 0.033$) for BNP and ST, respectively. The majority of the cohort was white (95%), and race did not differ by bladder neck dissection technique (Table 1). An extraperitoneal approach was performed in 50 men with previous abdominal surgery, without significant variation by bladder neck dissection technique. Furthermore, baseline urinary function, prostate-specific antigen, biopsy Gleason grade, nerve-sparing technique, prostate size, and pathologic stage grade were similar by bladder neck dissection technique. In addition, more men with clinical T1c disease underwent BNP versus ST (93.1% vs. 86.0%, $p = 0.002$) (Table 1). Successful BNP accounted for 4% in the first 100 men and steadily increased to 99.1% in the last 119 men in the series (Fig. 8). As BNP technique evolved from ST, mean follow-up was shorter for BNP versus ST (387.2 vs. 812.5 d; $p < 0.001$).

3.2. *Postoperative outcomes*

Perioperative complications and outcomes did not differ by bladder neck dissection technique; urine leaks, urinary retention, and bladder neck contractures were uncommon events (Table 2). One man undergoing BNP incurred a left ureteral injury due to an unrecognized complete duplication and required ureteral reimplantation. The overall positive margin rate (Table 3) was 12.8%, occurring at 10.5% in men with pT2 disease, 23.1% in pT3a, and 40.9% in pT3b disease ($p = 0.520$). Moreover, prostatic base positive-margin status was similar for men undergoing BNP versus ST (1.4% vs. 2.2%; $p = 0.547$).

At 4 mo postoperatively, mean urinary function scores were higher for BNP versus ST (Table 4) at 64.6 versus 57.2 ($p = 0.037$). Similarly, 4-mo continence rates (zero pads per

Table 1 – Patient demographics and tumor characteristics

	Bladder neck preservation $n = 348$	Standard technique $n = 271$	p value
Mean follow-up (d), mean ± SD (range)	387.2 ± 297. 2 (71–1368)	812.5 ± 246.2 (102–1432)	<0.001
Age (yr), mean ± SD	57.1 ± 6.6	58.9 ± 6.7	0.033
Race, no. (%)			
White	336 (96.6)	252 (93.3)	0.083
Black	9 (2.6)	11 (4.1)	–
Other	3 (0.9)	8 (3)	–
Preoperative urinary function, mean ± SD	96.0 ± 11.4	95.2 ± 11.8	0.303
PSA, mean ± SD	5.4 ± 2.8	5.8 ± 3.6	0.295
Clinical stage, no. (%)			
T1c	324 (93.1)	233 (86.0)	0.002
T2	24 (6.9)	38 (14.0)	–
Gleason grade (biopsy), no. (%)			
3 + 2	4 (1.1)	0	0.805
3 + 3	214 (61.4)	175 (64.6)	–
3 + 4	90 (25.8)	54 (20)	–
4 + 3	28 (8)	27 (10)	–
4 + 4	7 (2.0)	14 (5.2)	–
3 + 5	3 (0.9)	0	–
4 + 5	2 (0.6)	0	–
5 + 4	0	1 (0.4)	–

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

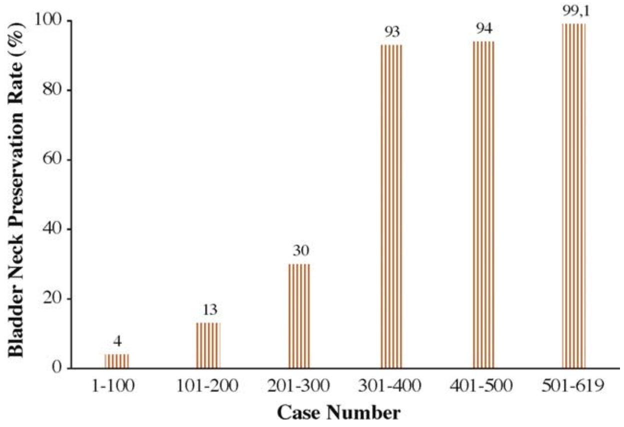


Fig. 8 – Progression of successful bladder neck preservation through the surgical series ($p < 0.001$).

day) were significantly higher for BNP versus ST (65.6% vs. 26.5%, $p < 0.001$). While urinary function and continence rates were similar at 12 mo, mean urinary function scores at 24 mo were significantly higher for BNP versus ST (94.1 vs. 86.8, $p < 0.001$). However, 24-mo continence rates were similar (>96%; $p = 0.308$) for both techniques.

4. Discussion

Bladder neck dissection is one of the most difficult steps for those transitioning from open to minimally-invasive approaches to radical prostatectomy [12]. While other steps of RALP diminished in complexity over the first 50 cases, the requisite time for bladder neck dissection increased [13]. The absence of tactile sensation and unfamiliar laparoscopic anatomy may prove challenging for those inexperienced with minimally-invasive approaches to radical prostatectomy as evidenced by the wide variation in techniques to

Table 2 – Perioperative outcomes

	Bladder neck preservation $n = 348$	Standard technique $n = 271$	p value
Estimated blood loss (ml), mean ± SD	183.7 ± 95.8	224.6 ± 108.0	0.938
Operative time (min), mean ± SD	152.8 ± 41.7	189.0 ± 42.1	0.460
Length of stay (d), mean ± SD	1.2 ± 0.76	1.3 ± 1.03	0.792
Length of catheterization (d), mean ± SD	7.7 ± 2.44	8.0 ± 3.97	0.996
Urinary retention*, no. (%)	14 (4)	6 (2.2)	0.256
Bladder neck contracture, no. (%)	4 (1.1)	2 (0.7)	0.701
Urine leak, no. (%)	10 (2.8)	4 (1.5)	0.288
Ureteral injury, no. (%)	1** (0.3)	0	0.436

SD = standard deviation.
* Urinary retention defined as failure of voiding trial necessitating reinsertion of urethral catheter.
** Presence of duplicated system on side of injury.

Table 3 – Nerve-sparing and pathologic features by bladder neck dissection technique

	Bladder neck preservation $n = 348$	Standard technique $n = 271$	p value	Overall
Bilateral NS*	254 (80.2)	215 (76)	0.400	
Unilateral NS*	52 (15.6)	37 (13.8)		
None, no. (%)	28 (8.4)	16 (6)		
Gland size (pathology), mean ± SD	54.4 ± 20.2	56.3 ± 21.9	0.503	–
Pathologic Gleason grade, no. (%)**				
3 + 2	0	2 (0.7)	0.708	2 (0.3)
3 + 3	143 (41.1)	122 (45.0)	–	265 (42.8)
3 + 4	138 (39.6)	90 (33.3)	–	228 (36.8)
3 + 5	2 (0.6)	1 (0.4)	–	3 (0.5)
4 + 3	47 (13.5)	32 (11.8)	–	79 (12.7)
4 + 4	10 (2.9)	11 (4.1)	–	21 (3.4)
4 + 5	5 (1.4)	9 (3.3)	–	14 (2.7)
5 + 3	0	1 (0.4)	–	1 (0.16)
Pathologic stage**				
pT2	295 (85.5)	231 (86.1)	0.161	526 (85)
pT3a	38 (11)	27 (10.1)	–	65 (10.5)
pT3b	12 (3.5)	10 (3.1)	–	22 (3.5)
Positive margins, no. (%)				
pT2	27 (9.2)	28 (12.1)	0.520	55 (10.5)
pT3a	9 (23.7)	6 (22.2)	–	15 (23.1)
pT3b	6 (50)	3 (30)	–	9 (40.9)
Positive margin at prostate base, no. (%)	5 (1.4)	6 (2.2)	0.547	11 (1.8)
Positive margins (overall), no. (%)	42 (12.1)	37 (13.7)	0.567	79 (12.8)

NS = nerve sparing; SD = standard deviation.
*17 men with missing NS information; **6 men were staged as pT0.

Table 4 – Comparison of patient self-reported postoperative recovery of urinary function and continence (zero pads per day)

Postoperative time (mo)	Sample size		Urinary function Mean ± SD			Continence* rate (%) Mean		
	Bladder neck preservation	Standard technique	Bladder neck preservation	Standard technique	*p* value	Bladder neck preservation	Standard technique	*p* value
4	224	223	64.6 ± 25.9	57.2 ± 24.1	0.037	65.6	26.5	<0.001
12	125	247	80.6 ± 18.7	79.0 ± 19.4	0.495	86.4	81.4	0.303
24	42	128	94.1 ± 10.6	86.8 ± 12.6	<0.001	100	96.1	0.308

SD = standard deviation.
*Continence defined as zero pads per day or pad free.

facilitate this step [4,14]. For instance, Garrett et al use a Lowsley retractor to elevate the bladder neck to define the prostate-vesical junction [15], while others recommended intraoperative ultrasonography [16] or simultaneous use of cystoscopy to help identifying the bladder neck [5]. Once the plane of incision has been identified, exposure may prove difficult. Others employ an additional suprapubic puncture site to snare the catheter tip with a suture that places tension on the catheter, thereby improving exposure and allowing the surgeon and assistant to keep their instruments free to work at the point of bladder neck dissection [17].

BNP is one variation of the bladder neck dissection that has been associated with several advantages over the ST, including a lower risk of bladder neck contracture [18] and lower rates of ureteral injury [14]. In addition, a large bladder neck requires time-consuming, reconstructive tapering and may be more susceptible to anastomotic leak due to the longer suture line.

Our paper has several notable findings. First, we present anatomic landmarks and technical modifications that lead to consistent bladder neck sparing with minimization of monopolar cautery. BNP was performed with more consistency over time and plateaued after approximately 300 cases. The premise of our technique is sharp cold-scissor dissection of natural tissue planes rather than use of monopolar energy or ultrasonic shears to create surgical planes. With monopolar electrosurgery, the patient is a part of the electrical circuit, and the path of the current may not correlate with anatomic distances [19]. Conversely, bipolar electrosurgery eliminates the patient from the circuit. The use of thermal energy during bladder neck transection is common, and the cautery tip may come within millimeters of the prostatic vascular pedicle [20]. While the prostate vascular pedicles may serve as a heat sink for energy sources [20], a study of the use of energy in proximity to the periprostatic neurovascular bundle in canines demonstrated diminished erectile function [19]. Furthermore, we use the fat pad of Whitmore as the posterolateral limit of the bladder neck dissection, as it is located in close proximity to the prostatic vascular pedicle and neurovascular bundle components. Finally, while our one-handed assistant technique of creating Foley catheter tension to elevate the prostate may not be superior to other described techniques, it is efficient and does not employ additional surgical steps or instrumentation.

Second, our technique of BNP versus nonpreservation is associated with improved early and late urinary function and better early continence. The discordance between 24-mo urinary function scores parallels the finding of Krupski et al that dichotomizing by pad use may not accurately portray continence, and continuous urinary function scores more accurately reflect health-related quality of life [21]. However, postoperative continence is frequently reported with such definitions as “socially dry” and “security liner” composed of one pad or more, which makes comparison between series more difficult [17,21]. Using a continence definition of no pad use, BNP versus ST was associated with better continence rates at 4 mo, while late continence was similar. Moreover, we identified improved early and late (4 and 24 mo) urinary function scores in men following RALP with BNP using a self-reported, validated quality-of-life instrument. Our results are consistent with the findings of others reporting better early continence with BNP during open radical prostatectomy BNP [22–25]. Additionally, earlier recovery of urinary function enhances quality of life [24].

It has been suggested that preservation of the bladder neck has no effect on continence but may instead compromise cancer control by increasing the likelihood of positive margins at the prostate base [26–28], adversely affecting cancer control [29]. However, we did not observe an increased risk of positive margins at the prostate base with BNP. Similar equivalent findings regarding cancer control have been reported for open radical prostatectomy BNP [18,22,23,30].

Our findings should be interpreted in the context of the study design. First, progression through the learning curve affects outcomes such as operative time and blood loss. While absence of bladder neck reconstruction decreases operative time, we concede that variation in bladder neck dissection technique is not solely responsible for shorter operative times and lower blood loss, and therefore we adjusted for temporal trends and potential learning curve effects that may influence these outcomes. However, the complication and positive margin rates were similar by bladder neck dissection surgical technique. Moreover, the study was performed over a relatively short period of time (3.5 yr) by the same surgeon. Second, we had loss to follow-up, which is inevitable with patient travel to a tertiary referral center. Finally, this was not a randomized study, which is difficult to conduct with single-surgeon series and technique modifications, as a surgeon may develop bias and habits in surgical technique that preclude reversion to a past technique, namely, ST of bladder neck dissection.

5. Conclusions

Our technique of anatomic BNP is consistently reproducible and improves urinary function and continence without compromising cancer control.

Author contributions: Marcos P. Freire 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: Freire, Hu.
Acquisition of data: Lei, Freire, Weinberg, Hu, Lin.
Analysis and interpretation of data: Hu, Freire, Lipsitz, Soukup.
Drafting of the manuscript: Freire, Hu, Prasad.
Critical revision of the manuscript for important intellectual content: Hu.
Statistical analysis: Lipsitz, Soukup.
Obtaining funding: None.
Administrative, technical, or material support: None.
Supervision: Hu.
Other (specify): Art: Korkes.

Financial disclosures: I certify that all conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript (eg, employment/affiliation, grants or funding, consultancies, honoraria, stock ownership or options, expert testimony, royalties, or patents filed, received, or pending), are the following: None.

Funding/Support and role of the sponsor: None.

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.2009.09.017 and via www.europeanurology.com. Subscribers to the printed journal will find the Surgery in Motion DVD enclosed.

References

[1] Hu JC, Wang Q, Pashos CL, Lipsitz SR, Keating NL. Utilization and outcomes of minimally invasive radical prostatectomy. J Clin Oncol 2008;10;26:2278–84.
[2] Herrell SD, Smith Jr JA. Robotic-assisted laparoscopic prostatectomy: what is the learning curve? Urology 2005;66(Suppl):105–7.
[3] Chin JL, Luke PP, Pautler SE. Initial experience with robotic-assisted laparoscopic radical prostatectomy in the Canadian health care system. Can Urol Assoc J 2007;1:97–101.
[4] Tewari AK, Rao SR. Anatomical foundations and surgical manoeuvres for precise identification of the prostatovesical junction during robotic radical prostatectomy. BJU Int 2006;98:833–7.
[5] Bird VG, Reese J, Winfield HN. Identification and dissection of bladder neck during laparoscopic radical prostatectomy. Urology 2002;60:680–1.
[6] Menon M, Shrivastava A, Kaul S, et al. Vattikuti Institute prostatectomy: contemporary technique and analysis of results. Eur Urol 2007;51:648–58, discussion 657–8.
[7] Berry AM, Korkes F, Ferreira M, Hu JC. Robotic urethrovesical anastomosis: combining running and interrupted sutures. J Endourol 2008;22:2127–9.
[8] Myers RP. Detrusor apron, associated vascular plexus, and avascular plane: relevance to radical retropubic prostatectomy–anatomic and surgical commentary. Urology 2002;59:472–9.
[9] Gil Vernet S. Morphology and function of vesico-prostato-urethral musculature. Treviso, Italy: Edizioni di Urologia; 1968. p. 334.
[10] Lepor H, Gregerman M, Crosby R, Mostofi FK, Walsh PC. Precise localization of the autonomic nerves from the pelvic plexus to the corpora cavernosa: a detailed anatomical study of the adult male pelvis. J Urol 1985;133:207–12.
[11] Wei JT, Dunn RL, Litwin MS, Sandler HM, Sanda MG. Development and validation of the expanded prostate cancer index composite (EPIC) for comprehensive assessment of health-related quality of life in men with prostate cancer. Urology 200020;56:899–905.
[12] Ahlering TE, Skarecky D, Lee D, Clayman RV. Successful transfer of open surgical skills to a laparoscopic environment using a robotic interface: initial experience with laparoscopic radical prostatectomy. J Urol 2003;170:1738–41.
[13] Thiel DD, Francis P, Heckman MG, Winfield HN. Prospective evaluation of factors affecting operating time in a residency/fellowship training program incorporating robot-assisted laparoscopic prostatectomy. J Endourol 2008;22:1331–8.
[14] Jenkins LC, Nogueira M, Wilding GE, et al. Median lobe in robot-assisted radical prostatectomy: evaluation and management. Urology 2008;71:810–3.
[15] Garrett JE, LaGrange CA, Chenven E, Strup SE. Use of Lowsley tractor during laparoscopic prostatectomy to reduce urethrovesical anastomotic tension. J Endourol 2006;20:220–2.
[16] Ukimura O, Gill IS, Desai MM, et al. Real-time transrectal ultrasonography during laparoscopic radical prostatectomy. J Urol 2004;172:112–8.
[17] Murphy DG, Kerger M, Crowe H, Peters JS, Costello AJ. Operative details and oncological and functional outcome of robotic-assisted laparoscopic radical prostatectomy: 400 cases with a minimum of 12 months follow-up. Eur Urol 2009;55:1358–67.
[18] Licht MR, Klein EA, Tuason L, Levin H. Impact of bladder neck preservation during radical prostatectomy on continence and cancer control. Urology 1994;44:883–7.
[19] Ong AM, Su LM, Varkarakis I, et al. Nerve sparing radical prostatectomy: effects of hemostatic energy sources on the recovery of cavernous nerve function in a canine model. J Urol 2004;172:1318–22.
[20] Khan F, Rodriguez E, Finley DS, Skarecky DW, Ahlering TE. Spread of thermal energy and heat sinks: implications for nerve-sparing robotic prostatectomy. J Endourol 2007;21:1195–8.
[21] Krupski TL, Saigal CS, Litwin MS. Variation in continence and potency by definition. J Urol 2003;170:1291–4.
[22] Gomez CA, Soloway MS, Civantos F, Hachiya T. Bladder neck preservation and its impact on positive surgical margins during radical prostatectomy. Urology 1993;42:689–93, discussion 693–4.
[23] Soloway MS, Neulander E. Bladder-neck preservation during radical retropubic prostatectomy. Semin Urol Oncol 2000;18:51–6.
[24] Selli C, De Antoni P, Moro U, Macchiarella A, Giannarini G, Crisci A. Role of bladder neck preservation in urinary continence following radical retropubic prostatectomy. Scand J Urol Nephrol 2004;38:32–7.
[25] Lowe BA. Comparison of bladder neck preservation to bladder neck resection in maintaining prostatectomy urinary continence. Urology 1996;48:889–93.
[26] Marcovich R, Wojno KJ, Wei JT, Rubin MA, Montie JE, Sanda MG. Bladder neck-sparing modification of radical prostatectomy adversely affects surgical margins in pathologic T3a prostate cancer. Urology 2000;55:904–8.

[27] Katz R, Salomon L, Hoznek A, de la Taille A, Antiphon P, Abbou CC. Positive surgical margins in laparoscopic radical prostatectomy: the impact of apical dissection, bladder neck remodeling and nerve preservation. J Urol 2003;169:2049–52.

[28] Srougi M, Nesrallah LJ, Kauffmann JR, Nesrallah A, Leite KR. Urinary continence and pathological outcome after bladder neck preservation during radical retropubic prostatectomy: a randomized prospective trial. J Urol 2001;165:815–8.

[29] Aydin H, Tsuzuki T, Hernandez D, Walsh PC, Partin AW, Epstein JI. Positive proximal (bladder neck) margin at radical prostatectomy confers greater risk of biochemical progression. Urology 2004;64:551–5.

[30] Bianco FJ, Grignon DJ, Sakr WA, et al. Radical prostatectomy with bladder neck preservation: impact of a positive margin. Eur Urol 2003;43:461–6.

EUROPEAN UROLOGY 58 (2010) 875–881

available at www.sciencedirect.com
journal homepage: www.europeanurology.com

European Association of Urology

Surgery in Motion

Randomized Controlled Trial of Barbed Polyglyconate Versus Polyglactin Suture for Robot-Assisted Laparoscopic Prostatectomy Anastomosis: Technique and Outcomes

Stephen B. Williams[a,1], *Mehrdad Alemozaffar*[a,1], *Yin Lei*[a], *Nathanael Hevelone*[b], *Stuart R. Lipsitz*[b], *Blakely A. Plaster*[a], *Jim C. Hu*[a,b,*]

[a] *Division of Urologic Surgery, Brigham and Women's Hospital, Boston, MA, USA*
[b] *Center for Surgery and Public Health, Brigham and Women's Hospital, Boston, MA, USA*

Article info

Article history:
Accepted July 13, 2010
Published online ahead of print on August 2, 2010

Keywords:
Radical prostatectomy
Robotic
Anastomosis
Complications
Quill
Suture
Urine leak
Continence

Please visit www.europeanurology.com and www.urosource.com to view the accompanying video.

Abstract

Background: Transperitoneal robot-assisted laparoscopic prostatectomy (RALP) urethrovesical anastomosis is a critical step. Although the prevalence of urine leaks ranges from 4.5% to 7.5% at high-volume RALP centers, urine leaks prolong catheterization and may lead to ileus, peritonitis, and require intervention. Barbed polyglyconate sutures maintain running suture line tension and may be advantageous in RALP anastomosis for reducing this complication.
Objective: To compare barbed polyglyconate and polyglactin 910 (Vicryl, Ethicon, Somerville, NJ, USA) running sutures for RALP anastomosis.
Design, setting, and participants: This was a prospective, randomized, controlled, single-surgeon study comparing RALP anastomosis using either barbed polyglyconate ($n = 45$) or polyglactin 910 ($n = 36$) sutures.
Surgical procedure: RALP anastomosis using either barbed polyglyconate or polyglactin 910 sutures was studied.
Measurements: Operative time, cost differential, perioperative complications, and cystogram contrast extravasation by anastomosis suture type were measured.
Results and limitations: Although baseline characteristics and overall operative times were similar, barbed polyglyconate sutures were associated with shorter mean anastomosis times of 9.7 min versus 9.8 min ($p = 0.014$). In addition, anastomosis with barbed polyglyconate rather than polyglactin 910 sutures was associated with more frequent cystogram extravasation 8 d postoperatively (20.0% vs 2.8%; $p = 0.019$), longer mean catheterization times (11.1 d vs 8.3 d; $p = 0.048$), and greater suture costs per case ($51.52 vs $8.44; $p < 0.001$). After 8 of 29 (27.6%) barbed polyglyconate anastomosis sites demonstrated postoperative day 8 cystogram extravasation, we modified our technique to avoid overtightening, reducing cystogram extravasation to 1 (6.3%) of 16 subsequent barbed polyglyconate anastomosis sites. Potential limitations include small sample size and the single-surgeon study design.
Conclusions: Compared to traditional sutures, barbed polyglyconate is more costly and requires technical modification to avoid overtightening, delayed healing, and longer catheterization time following RALP.

---

[1] These authors share the first authorship.

[*] Corresponding author. Division of Urologic Surgery, Brigham and Women's Hospital, 75 Francis Street, Boston, MA 20015, USA. Tel. +1 617 732 4848; Fax: +1 617 566 3475.
E-mail address: jhu2@partners.org (J.C. Hu).

0302-2838/$ – see back matter © 2010 European Association of Urology. Published by Elsevier B.V. All rights reserved. doi:10.1016/j.eururo.2010.07.021

1. Introduction

Robot-assisted laparoscopic prostatectomy (RALP) has been rapidly adopted [1,2], and the robotic surgical platform facilitates the laparoscopic surgical approach [3,4]. However, anastomosis remains a challenging step in the RALP procedure. Although the prevalence of RALP urine leaks ranges from 4.5% to 7.5%, with Clavien classification reporting from high-volume referral centers [5,6], urine leaks prolong catheterization times and may require discharge with a drain lest they result in ileus, peritonitis, and hospital readmission. Moreover, urine leaks are associated with anastomotic strictures during open radical prostatectomy (RP) [7,8].

Barbed (Covidian; Mansfield, MA, USA) sutures have been applied in plastic and reconstructive surgery [9], gynecology [10], and porcine [11] and microfiber models [12] in urology. The unidirectional barbs maintain running suture line tension and purportedly obviate the need for knot tying. We hypothesized that barbed polyglyconate versus conventional suture material may reduce urine leaks and operative time. The purpose of our prospective, randomized study was to compare RALP anastomosis outcomes using barbed polyglyconate sutures versus polyglactin 910 (Vicryl, Ethicon, Somerville, NJ, USA) sutures. The accompanying video demonstrates our anastomosis technique and modifications developed for barbed polyglyconate suture use. Finally, we assessed RALP procedures performed prior to our trial to determine whether urine leaks were associated with reduced urinary function or more anastomotic strictures.

2. Methods

2.1. Enrollment

Our prospective, randomized, controlled trial of barbed polyglyconate versus polyglactin 910 sutures in 82 men undergoing RALP was approved by the Brigham and Women's Hospital institutional review board and conducted between February and May 2010 (Fig. 1). Prior to initiation of the study, the surgeon (JCH) logged 397 RALP procedures during fellowship training and 765 RALP procedures as an attending surgeon

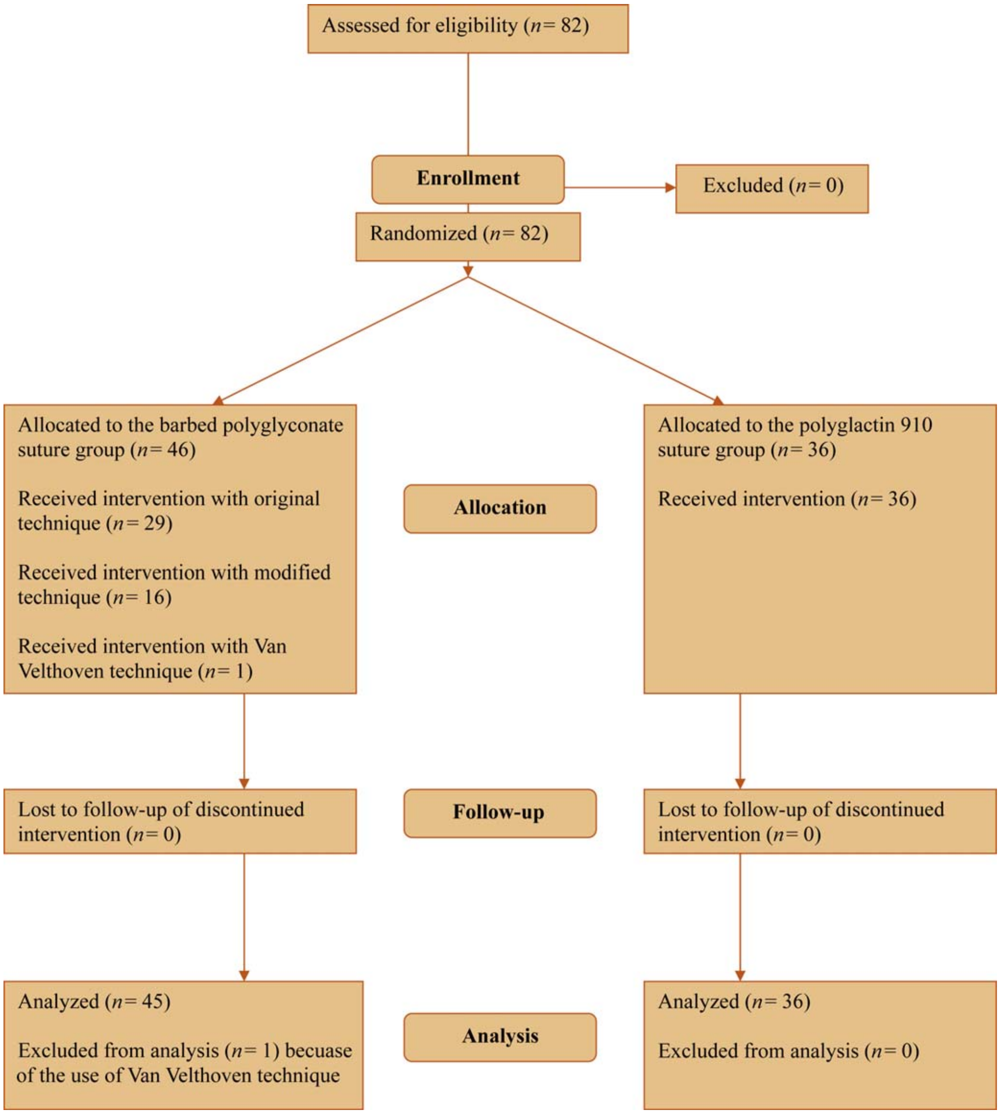


Fig. 1 – Consort diagram illustrating randomization study design.

using polyglactin 910 suture anastomosis from September 2005 through January 2010, but he did not have prior experience with barbed polyglyconate sutures. Primary outcomes of interest for the randomized trial included operative time, perioperative complications, length of catheterization time, and costs attributable to suture material. To assess potential long-term urine leak sequelae such as anastomotic strictures and incontinence, we assessed prospectively collected data from the 765 RALP procedures performed prior to the randomized trial.

2.2. *Surgical technique*

The sequential steps for our transperitoneal RALP approach [13] and urethrovesical anastomotic technique using a single posterior interrupted suture and two running sutures have been previously described [14]. Using a four-armed da Vinci S Surgical System (Intuitive Surgical, Sunnyvale, CA, USA), we perform a completely antegrade approach in the following order: (1) bladder neck and seminal vesicle dissection, (2) antegrade nerve sparing, (3) apical dissection, and (4) anastomosis. Bladder neck preservation was carried out in all men. Moreover, to limit needle exchanges, we divide the dorsal venous complex (DVC) and the anterior urethra, leaving the posterior urethra as the only remaining attachment of the prostate. To minimize bleeding from the DVC that may occur without prior suture ligation, the assistant bedside surgeon counterintuitively minimizes suctioning, because it lowers the pneumoperitoneum and exacerbates venous bleeding [13]. The robotic Maryland bipolar and curved scissors are then exchanged for a large robotic suture cut and regular needle driver. This is the first and only robotic instrument change. A 3-0 polyglactin 910 suture cut to 23 cm is then used to ligate the DVC. The same suture is placed in an inside-out fashion through the urethra at the 6 o'clock position (Fig. 2) prior to division of the posterior urethra with standard laparoscopic scissors by the assistant bedside surgeon to avoid switching back to the robotic curved scissors (Fig. 3). After placement of the specimen into a laparoscopic bag and irrigation of the prostatic fossa, the 6 o'clock anastomotic suture is placed in an outside-in fashion through the bladder, and a surgeon's knot placed on the bladder mucosa parachutes and secures the bladder down to the urethra (Fig. 4). With our standard polyglactin 910 anastomosis, the remaining suture material is used as the 5 o'clock anastomotic suture (with the knot placed on the bladder mucosa) and run to 12 o'clock. Thus, the original suture was cut to a longer length for DVC ligation, the posterior interrupted 6 o'clock, and one of the running sutures that comprise half of the anastomosis. Using the same suture limits needle exchanges and promotes efficiency.

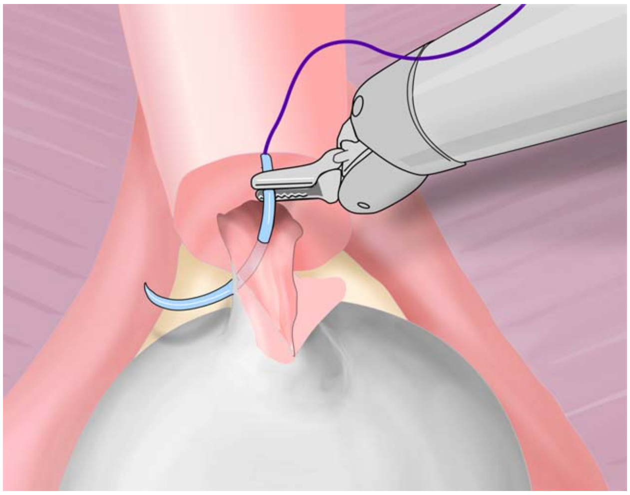


Fig. 2 – Six o'clock anastomotic suture placed inside-out of the urethral mucosa prior to transection of the posterior urethra to avoid retraction of the urethral stump.

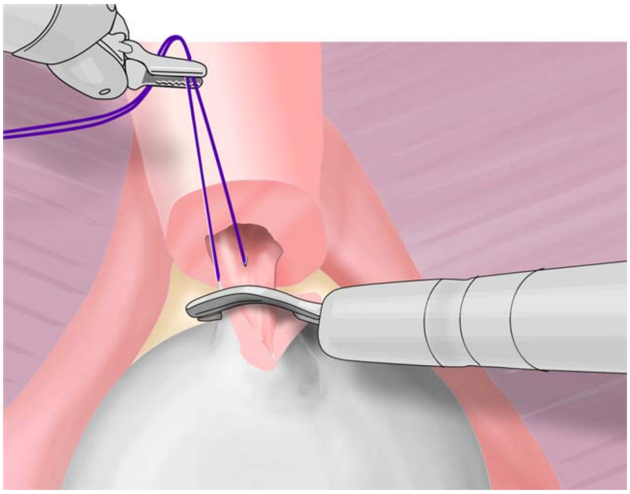


Fig. 3 – An assistant divides the posterior urethra with laparoscopic scissors to avoid additional robotic instrument change, and the specimen is placed into a laparoscopic bag.

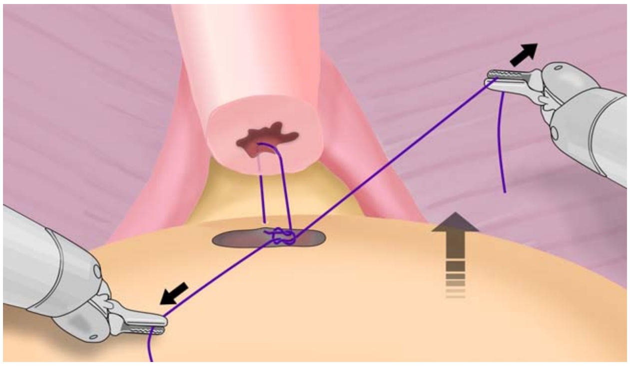


Fig. 4 – A surgeon's knot on the bladder mucosa is used to parachute down the bladder. Tying the knot on the inside versus the outside of the anastomosis allows the surgeon to directly visualize the suture and ensure that the knot is down.

In a mirror-image fashion, another 3-0 polyglactin 910 suture cut to 18 cm is knotted at 7 o'clock and run to 12 o'clock, forming the other half of the anastomosis. To promote efficiency of the running sutures, the needles are passed outside-in the bladder and inside-out the urethra in one throw. Moreover, the suture is pulled through perpendicular to the urethral stump rather than pulling it back toward the camera, which results in the suture taking a U-turn through the urethral wall and increases the risk of sawing through and causing a urethral tear. Simultaneously, the other needle driver forms a "V" where the suture exits the urethra and buttresses as slack is removed from the suture line (Fig. 5). At the anterior anastomosis, both sutures exit the urethra side because of the one-bite technique described above. One running suture is passed through the anastomosis inside-out of the bladder to allow knotting across the anterior anastomosis. The bladder is filled with 120 ml of irrigation, and the 16F working catheter is exchanged for the 20F final catheter.

A 15F Blake drain is placed at the fourth robotic arm trocar site located medial to the left anterior superior iliac spine. The drain was removed when output was <50 ml over 8 h, and all men received ketorolac around the clock and intravenous or oral narcotics for breakthrough pain. All men were discharged on the first postoperative day without a drain and underwent cystograms on postoperative day 8; urinary catheters were

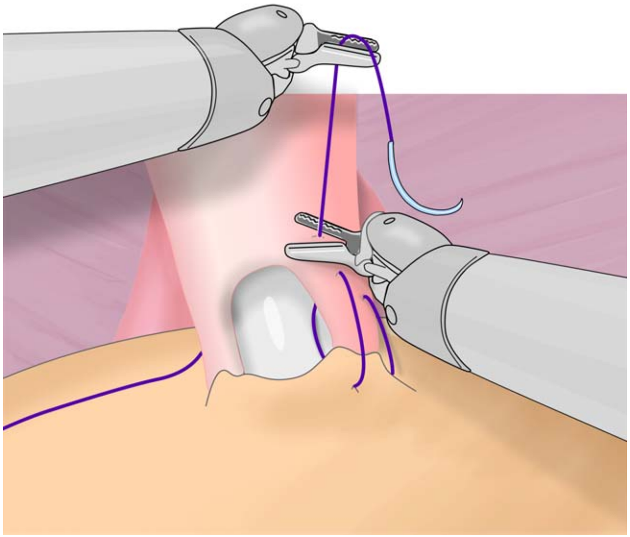


Fig. 5 – To remove slack from the suture line during the running component of the anastomosis, the suture is pulled through perpendicular to the urethral stump versus pulling it back toward the camera. Simultaneously, the other needle driver forms a "V" where the suture exits the urethra and buttresses as slack is removed from the suture line. However, this maneuver must be avoided with barbed polyglyconate sutures to avoid overtightening and potential tissue strangulation.

removed if contrast extravasation was absent. If extravasation was present, cystograms were repeated weekly until extravasation resolved or a limited extraperitoneal leak was demonstrated. At this point, urinary catheters were removed.

Men were randomized to either barbed polyglyconate or polyglactin 910 sutures when scheduled for surgery using Random.org's Random Integer Generator (https://www.random.org/integers) to generate an integer between 1 and 2 for each subject; subjects assigned a 1 were placed in the barbed polyglyconate suture group, and those assigned a 2 were placed in the polyglactin 910 suture group. For men randomized to the barbed polyglyconate suture group, 3-0 polyglactin 910 suture was used for dorsal vein ligation and the posterior 6 o'clock suture, as mentioned previously. However, two barbed polyglyconate sutures were passed inside-out the urethra and outside-in the bladder mucosa at 5 o'clock and 7 o'clock before each needle was passed through its corresponding manufactured loop end to initiate the suture line at the respective locations. The running barbed polyglyconate suture completed the anastomosis in the same fashion as described above for polyglactin 910. The surgical technique was the same for the barbed polyglyconate and polyglactin 910 suture groups; however, we avoided overtightening (Fig. 5) in 16 barbed polyglyconate subjects after disappointing results for the initial 29 barbed polyglyconate subjects. One subject for whom we passed the barbed polyglyconate suture through the manufactured loop of another barbed polyglyconate suture to form a double-armed suture for Van Velthoven anastomosis was excluded from the study [15].

2.3. Outcome measures

Data were collected prospectively by research personnel uninvolved with clinical care. Operative time comprised the interim between Veress needle insertion and completion of skin closure, while anastomosis time comprised the interim between 6 o'clock anastomotic suture placement/division of the posterior urethra and the knotting of the running sutures at 12 o'clock. Contrast extravasation on postoperative day 8 cystogram was characterized as delayed healing; postoperative day of catheter removal was defined as length of catheterization time. Moreover, to determine whether the barbed polyglyconate suture were associated with a greater degree of gross hematuria, clinicians prospectively assessed whether there was a reddish tint to the catheter output versus clear or tea-colored urine at the time of postoperative cystograms. Men with gross hematuria were asked when they first observed gross hematuria. Deviations from the normal perioperative course were noted.

Finally, 765 RALP procedures performed prior to the randomized trial were assessed to determine whether urine leaks were associated with a greater risk for anastomotic strictures or decreased urinary control, as measured by the urinary function scale of the Expanded Prostate Cancer Index [16]. The urinary function scale is scored from 0 to 100, with higher scores representing better outcomes.

2.4. Power calculation and statistical analysis

The urine leak rate was 3.5% for the 765 RALP polyglactin 910 anastomosis procedures performed prior to randomization, and we hypothesized that use of barbed polyglyconate sutures would eliminate urine leaks. Power calculations revealed that a total of 94 subjects in the barbed polyglyconate and polyglactin 910 study arms, respectively, provides 80% power at a significance level of 0.05 to detect at least a 3.4% improvement in urine leak complications. However, barbed polyglyconate suture leaks were more frequent than anticipated and costs were significantly higher for barbed polyglyconate sutures versus polyglactin 910 sutures and postoperative cystograms. Consequently, the study was terminated and data analyzed prior to enrollment targets being met because barbed polyglyconate suture superiority was not demonstrable.

We used the 2-sided student t test to compare continuous variables; we used the Fisher exact test and the Pearson χ^2 test to compare categorical variables. A 2-sided result of $p < 0.05$ was considered statistically significant. All statistical analyses were performed using SAS v.9.2 (SAS Institute, Cary, NC, USA).

3. Results

Table 1 shows demographic and biopsy characteristics, which did not differ by suture anastomosis type. Table 2 shows perioperative outcomes. Although the mean anastomosis time was statistically shorter for barbed polyglyconate suture versus polyglactin 910 suture (9.7 min vs 9.8 min; $p = 0.014$), there was no difference in the overall operative times (103.8 min vs 110.4 min; $p = 0.163$; Table 2). Moreover, we experienced difficulty with the catheter exchange after completion of the anastomosis in four barbed polyglyconate suture cases versus zero polyglactin 910 suture RALP anastomosis cases. For three men, a 20F coude catheter traversed the anastomosis successfully; this maneuver failed for one man, who required flexible cystoscopy and council tip catheter placement over a guidewire. Interestingly, none of these men experienced contrast extravasation on postoperative day 8. However, overall, barbed polyglyconate suture versus polyglactin 910 suture was associated with more frequent contrast extravasation on postoperative day 8 cystograms (20.0% vs 2.8%; $p = 0.019$) and longer catheterization times (11.1 d vs 8.3 d; $p = 0.048$). The same subjects experiencing cystogram contrast extravasation also had gross hematuria at the time of cystograms, and these men reported that they were discharged with clear urine that became bloody between postoperative days 5 and 7. Furthermore, the degree of barbed polyglyconate suture

Table 1 – Comparison of preoperative characteristics by suture type

	Barbed polyglyconate ($n = 45$)	Polyglactin 910 ($n = 36$)	p value
Age, yr, mean (SD)	59.0 (7.0)	60.3 (5.1)	0.357
BMI, kg/m^2, mean (SD)	28.4 (4.1)	28.3 (5.3)	0.884
Baseline urinary function, mean (SD)	96.7 (8.2)	98.5 (4.4)	0.220
Baseline sexual function, mean (SD)	72.8 (27.0)	72.9 (27.0)	0.989
Caucasian race, No. (%)	41 (91.1)	32 (88.9)	0.739
PSA, ng/ml, mean (SD)	6.7 (3.0)	6.1 (4.5)	0.543
Clinical stage, No. (%)			
T1c	43 (95.6)	36 (100)	0.440
T2a	1 (2.2)	0 (0)	–
T2b	1 (2.2)	0 (0)	–
Past medical history, No. (%)			
Hypertension	9 (20)	8 (22.2)	0.807
Diabetes	0 (0)	2 (5.6)	0.109
Smoking	7 (15.6)	6 (16.7)	0.892

SD = standard deviation; BMI = body mass index; PSA = prostate-specific antigen.

Table 2 – Comparison of operative characteristics by suture type

	Barbed polyglyconate ($n = 45$)	Polyglactin 910 ($n = 36$)	p value
Operative time, min, mean (SD)	103.8 (21.2)	110.4 (19.4)	0.163
Anastomosis time, min, mean (SD)	9.7 (0.2)	9.8 (0.2)	0.014
Contrast extravasation on postoperative day 8, No. (%)	9 (20)	1 (2.8)	0.019
Length of catheterization, d, mean (SD)	11.1 (8.3)	8.3 (3.8)	0.048
Difficulty with intraoperative catheter change, No. (%)	4 (8.9)	0 (0)	0.125
EBL, ml, mean (SD)	181.5 (78.1)	173.3 (49.7)	0.580
Pathologic stage, No. (%)			
T2	39 (86.6)	29 (80.5)	0.553
T3a	3 (6.7)	5 (13.9)	–
T3b	3 (6.7)	2 (5.6)	–
PSM, No. (%)	5 (11.1)	4 (11.1)	1.000
Suture cost, US$	51.52	8.44	<0.001

SD = standard deviation; EBL = estimated blood loss; PSM = positive surgical margin.

cystogram extravasation worsened on postoperative day 15 cystograms.

The cost of two barbed polyglyconate suture cases and one polyglactin 910 suture case compared to two polyglactin 910 suture cases was $51.52 versus $8.44 ($p < 0.001$). After 8 cystogram leaks in the first 29 barbed polyglyconate suture subjects, we modified our technique to approximate the bladder and urethral stump without overtightening, avoiding the maneuver to cinch and remove running suture line slack (Fig. 5), resulting in only one cystogram leak in the subsequent 16 barbed polyglyconate suture subjects (27.5% vs 6.3%; $p = 0.127$).

Comparisons of RALP with and without urine leak performed prior to our randomized, controlled trial are shown in Table 3. Although men with and without urine leaks required longer catheterization times (17.8 d vs 7.6 d; $p < 0.001$), recovery of urinary function was similar for those with and without urine leaks at 6, 12, and 24 mo. Moreover,

Table 3 – Comparison of stricture rate and urinary function for robot-assisted laparoscopic prostatectomy with and without postoperative urinary leaks performed prior to the prospective randomized trial

	Urine leak ($n = 26$)	No urine leak ($n = 739$)	p value
Age at surgery, yr, mean (SD)	59.4 (6.8)	58.5 (6.8)	0.921
BMI, ml, mean (SD)	30.3 (5.1)	28.8 (4.7)	0.112
Baseline urinary function, mean (SD)	98.3 (4.8)	95.7 (11.3)	<0.001
Urinary function, No., mean (SD)			
6 mo	70.6 (34.2)	68.9 (26.7)	0.845
12 mo	77.0 (24.5)	78.5 (21.2)	0.804
24 mo	81.6 (19.3)	83.7 (21.6)	0.813
Anastomotic stricture, No. (%)	0 (0)	6 (0.8)	0.651

SD = standard deviation; BMI = body mass index.

the anastomotic stricture rate did not differ for men with versus without urine leaks (0% vs 0.8%; $p = 0.651$).

4. Discussion

Minimizing urine leak from the urethrovesical anastomosis—particularly with the transperitoneal approach—is critical during RALP, and the anastomosis is one of the most challenging steps of the procedure for novices [17]. Although our urine leak rate was relatively low in our RALP series that employed more bladder neck preservation over time [18], this complication prolongs catheterization time and may cause peritonitis and ileus requiring bowel rest and parenteral nutrition as well as require image-guided drain placement [5]. Therefore, we examined whether barbed polyglyconate sutures may offer advantages over polyglactin 910 sutures in terms of reducing urine leaks, operative time, and length of catheterization time. Barbed sutures were developed to allow tissue approximation with minimal tension and less foreign body reaction, which may lead to better wound healing [9,10,12,19].

Although performed in a microfiber model system, Moran et al sought to explore the use of a bidirectional barbed suture to create a hybrid of "suturing and gluing" when performing a knotless running anastomosis [12]. In addition, others have explored the use of barbed sutures in plastic and reconstructive procedures [9,20] and orthopedics [21] to repair tendons with less inflammatory reaction. The only other report on the use of a barbed suture urethrovesical anastomosis was in vitro [12], with limited data analysis; we sought to explore this concept in vivo.

Our paper has several important findings. First, technical adjustments must be made when transitioning from traditional suture materials such as polyglactin 910 or poliglecaprone 25 (Monocryl; Ethicon, Somerville, NJ, USA) to barbed polyglyconate for RALP anastomosis. Overtightening is problematic with barbed polyglyconate suture and may lead to delayed urine leak, the symptom being bloody urine after postoperative day 5. In addition, we observed greater contrast extravasation on the second versus first cystogram performed at day 15 versus day 8, suggesting that tissue necrosis may be the mechanism of injury. Moreover, the urine leak rate decreased after we did not tighten the suture line beyond the point of the bladder and the urethral tissue approximation. However, the barbed polyglyconate suture postmodification contrast extravasation rate was not superior to the polyglactin 910 suture group.

Second, the cost of barbed polyglyconate suture material compared to polyglactin 910 suture material and monofilaments such as poliglecaprone 25 is significantly higher. The retail price of barbed polyglyconate per suture is \$23.65, while polyglactin 910 and poliglecaprone 25 retail for \$4.22 and \$10.09, respectively; the greater barbed polyglyconate suture material expense exacerbates the cost disadvantage of RALP versus open RP. Zorn described the use of absorbable suture clips placed on the running suture to maintain tension, but these clips cost \$29.50 per clip [22]. In addition, although the difference in anastomosis time was statistically significant because of narrow variance from the mean barbed polyglyconate and polyglactin 910 anastomosis times, 6 s is not clinically significant and does not significantly reduce operating room costs. Therefore, surgeons should weigh their individual risk of urine leak and use absorbable suture clips or barbed polyglyconate suture material selectively to reduce costs. For instance, barbed polyglyconate sutures can be used for men with benign prostatic hyperplasia and larger bladder necks. Alternatively, neophyte robotic surgeons may prefer barbed polyglyconate sutures to minimize urine leaks early in the learning curve for performing the anastomosis. In addition, barbed polyglyconate sutures may be preferred in training settings; the attending surgeon can visualize tissue approximation with barbed polyglyconate sutures rather than relying on trainees to cinch and remove slack from the running suture line, which may be difficult for the attending surgeon to judge in terms of appropriate suture line tension.

Third, data from RALP procedures performed prior to our randomized trial did not reveal more anastomotic strictures or worse urinary function for men who experienced urinary leak complications versus those who did not. This is consistent with other RALP series [23]. In contrast, open RP urine leaks are associated with an increased risk for anastomotic strictures [7,8]. This conflicting evidence may result from differences between a running anastomosis versus interrupted sutures and/or differences in visualization for RALP versus open RP. However, for men requiring prolonged catheterization as a result of urine leaks, our findings may reassure them that they are not at increased risk for anastomotic stricture or incontinence.

Our findings should be interpreted in the context of the study design. First, although we used a prospective, randomized study design, this was a single-surgeon study, and our findings are dependent on surgeon-specific technique. For instance, more urine leaks may be expected with larger bladder necks or earlier in the RALP learning curve. However, our findings likely extend to anastomotic techniques that employ running sutures, such as the Van Velthoven technique [15]. In addition, we do not perform posterior reconstruction, which has been shown to reduce urine leaks [24]. Second, our sample size is relatively small, because we do not routinely perform cystograms on all RALP patients because of additional resource consumption; to demonstrate superiority to the polyglactin 910 group, we would have to perform another 275 barbed polyglyconate suture anastomosis procedures without cystogram contrast extravasation. Moreover, our small sample size limits interpretation of our findings beyond our barbed polyglyconate suture learning curve and technique modification, although outcomes appear similar to polyglactin 910 cases. Third, our method of identifying bloody urine postoperatively is subject to recall bias. Patient diaries may attenuate this bias, but this method may also result in more missing data for non-responders. Development of gross hematuria after RALP hospital discharge with previously clear urine may be a sign of incomplete anastomotic healing and may serve as a proxy to cystograms. In other words, surgeons may delay voiding trials until gross hematuria resolves. Finally, we do not have urinary function comparisons by suture material; however, comparison of prestudy patients did not reveal a difference in urinary function for RALP with and without urine leak.

5. Conclusions

Barbed polyglyconate sutures are more costly than traditional sutures and require technical modification to avoid overtightening, delayed healing, and longer catheterization times following RALP.

Author contributions: Stephen B. Williams 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: Williams, Hu.
Acquisition of data: Alemozaffar, Lei, Hevelone, Lipsitz, Plaster, Hu.
Analysis and interpretation of data: Williams, Alemozaffar, Lei, Hevelone, Lipsitz, Plaster, Hu.
Drafting of the manuscript: Williams, Alemozaffar, Lei, Hevelone, Lipsitz, Plaster, Hu.
Critical revision of the manuscript for important intellectual content: Williams, Alemozaffar, Lei, Hevelone, Lipsitz, Plaster, Hu.
Statistical analysis: Hevelone, Lipsitz, Hu.
Obtaining funding: None.
Administrative, technical, or material support: Hu.
Supervision: Hu.
Other (specify)*:* None.

Financial disclosures: I certify that all conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript (eg, employment/affiliation, grants or funding, consultancies, honoraria, stock ownership or options, expert testimony, royalties, or patents filed, received, or pending), are the following: None.

Funding/Support and role of the sponsor: None.

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.2010.07.021 and via www.europeanurology.com. Subscribers to the printed journal will find the Surgery in Motion DVD enclosed.

References

[1] Hu JC, Wang Q, Pashos CL, Lipsitz SR, Keating NL. Utilization and outcomes of minimally invasive radical prostatectomy. J Clin Oncol 2008;26:2278–84.

[2] Hu JC, Gu X, Lipsitz SR, et al. Comparative effectiveness of minimally invasive vs open radical prostatectomy. JAMA 2009;302:1557–64.

[3] Ficarra V, Novara G, Artibani W, et al. Retropubic, laparoscopic, and robot-assisted radical prostatectomy: a systematic review and cumulative analysis of comparative studies. Eur Urol 2009;55:1037–63.

[4] Ficarra V, Cavalleri S, Novara G, Aragona M, Artibani W. Evidence from robot-assisted laparoscopic radical prostatectomy: a systematic review. Eur Urol 2007;51:45–56, discussion 56.

[5] Hu JC, Nelson RA, Wilson TG, et al. Perioperative complications of laparoscopic and robotic assisted laparoscopic radical prostatectomy. J Urol 2006;175:541–6, discussion 546.

[6] Murphy DG, Kerger M, Crowe H, Peters JS, Costello AJ. Operative details and oncological and functional outcome of robotic-assisted laparoscopic radical prostatectomy: 400 cases with a minimum of 12 months follow-up. Eur Urol 2009;55:1358–67.

[7] Surya BV, Provet J, Johanson KE, Brown J. Anastomotic strictures following radical prostatectomy: risk factors and management. J Urol 1990;143:755–8.

[8] Kostakopoulos A, Argiropoulos V, Protogerou V, Tekerlekis P, Melekos M. Vesicourethral anastomotic strictures after radical retropubic prostatectomy: the experience of a single institution. Urol Int 2004;72:17–20.

[9] Warner JP, Gutowski KA. Abdominoplasty with progressive tension closure using a barbed suture technique. Aesthet Surg J 2009;29: 221–5.

[10] Greenberg JA, Einarsson JI. The use of bidirectional barbed suture in laparoscopic myomectomy and total laparoscopic hysterectomy. J Minim Invasive Gynecol 2008;15:621–3.

[11] Shikanov S, Wille M, Large M, et al. Knotless closure of the collecting system and renal parenchyma with a novel barbed suture during laparoscopic porcine partial nephrectomy. J Endourol 2009;23: 1157–60.

[12] Moran ME, Marsh C, Perrotti M. Bidirectional-barbed sutured knotless running anastomosis v classic Van Velthoven suturing in a model system. J Endourol 2007;21:1175–8.

[13] Freire MP, Choi WW, Lei Y, Carvas F, Hu JC. Overcoming the learning curve for robotic-assisted laparoscopic radical prostatectomy. Urol Clin North Am 2010;37:37–47.

[14] Berry AM, Korkes F, Ferreira M, Hu JC. Robotic urethrovesical anastomosis: combining running and interrupted sutures. J Endourol 2008; 22:2127–9.

[15] Van Velthoven RF, Ahlering TE, Peltier A, Skarecky DW, Clayman RV. Technique for laparoscopic running urethrovesical anastomosis: the single knot method. Urology 2003;61:699–702.

[16] Wei JT, Dunn RL, Litwin MS, Sandler HM, Sanda MG. Development and validation of the expanded prostate cancer index composite (EPIC) for comprehensive assessment of health-related quality of life in men with prostate cancer. Urology 2000;56:899–905.

[17] Thiel DD, Francis P, Heckman MG, Winfield HN. Prospective evaluation of factors affecting operating time in a residency/fellowship training program incorporating robot-assisted laparoscopic prostatectomy. J Endourol 2008;22:1331–8.

[18] Freire MP, Weinberg AC, Lei Y, et al. Anatomic bladder neck preservation during robotic-assisted laparoscopic radical prostatectomy: description of technique and outcomes. Eur Urol 2009;56:972–80.

[19] Ruff G. Technique and uses for absorbable barbed sutures. Aesthet Surg J 2006;26:620–8.

[20] Rachel JD, Lack EB, Larson B. Incidence of complications and early recurrence in 29 patients after facial rejuvenation with barbed suture lifting. Dermatol Surg 36:348–54.

[21] Trocchia AM, Aho HN, Sobol G. A re-exploration of the use of barbed sutures in flexor tendon repairs. Orthopedics. In press. doi:10.3928/01477447-20090818-12.

[22] Zorn KC. Robotic radical prostatectomy: assurance of water-tight vesicourethral anastomotic closure with the Lapra-Ty clip. J Endourol 2008;22:863–5.

[23] Blumenthal KB, Sutherland DE, Wagner KR, Frazier HA, Engel JD. Bladder neck contractures related to the use of Hem-o-lok clips in robot-assisted laparoscopic radical prostatectomy. Urology 2008; 72:158–61.

[24] Menon M, Hemal AK, Tewari A, Shrivastava A, Bhandari A. The technique of apical dissection of the prostate and urethrovesical anastomosis in robotic radical prostatectomy. BJU Int 2004;93: 715–9.

EUROPEAN UROLOGY 59 (2011) 235–243

available at www.sciencedirect.com
journal homepage: www.europeanurology.com

European Association of Urology

Surgery in Motion

Athermal Division and Selective Suture Ligation of the Dorsal Vein Complex During Robot-Assisted Laparoscopic Radical Prostatectomy: Description of Technique and Outcomes

Yin Lei [a,1], *Mehrdad Alemozaffar* [a,1], *Stephen B. Williams* [a], *Nathanael Hevelone* [b], *Stuart R. Lipsitz* [b,c], *Blakely A. Plaster* [a], *Channa A. Amarasekera* [c], *William D. Ulmer* [c], *Andy C. Huang* [a], *Keith J. Kowalczyk* [a], *Jim C. Hu* [a,b,c,*]

[a] *Division of Urologic Surgery, Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA*
[b] *Center for Surgery and Public Health, Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA*
[c] *Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA*

Article info

Article history:
Accepted August 26, 2010
Published online ahead of print on September 15, 2010

Keywords:
Radical prostatectomy
Continence
Outcomes
Robotic surgical technique

Please visit www.europeanurology.com and www.urosource.com to view the accompanying video.

Abstract

Background: Apical dissection and control of the dorsal vein complex (DVC) affects blood loss, apical positive margins, and urinary control during robot-assisted laparoscopic radical prostatectomy (RALP).

Objective: To describe technique and outcomes for athermal DVC division followed by selective suture ligation (DVC-SSL) compared with DVC suture ligation followed by athermal division (SL-DVC).

Design, settings, and participants: Retrospective study of prospectively collected data from February 2008 to July 2010 for 303 SL-DVC and 240 DVC-SSL procedures.

Surgical procedure: RALP with comparison of DVC-SSL prior to anastomosis versus early SL-DVC prior to bladder-neck dissection.

Measurements: Blood loss, transfusions, operative time, apical and overall positive margins, urine leaks, catheterization duration, and urinary control at 5 and 12 mo evaluated using 1) the Expanded Prostate Cancer Index (EPIC) urinary function scale and 2) continence defined as zero pads per day.

Results and limitations: Men who underwent DVC-SSL versus SL-DVC were older (mean: 59.9 vs 57.8 yr, $p < 0.001$), and relatively fewer white men underwent DVC-SSL versus SL-DVC (87.5% vs 96.7%, $p < 0.001$). Operative times were also shorter for DVC-SSL versus SL-DVC (mean: 132 vs 147 min, $p < 0.001$). Men undergoing DVC-SSL versus SL-DVC experienced greater blood loss (mean: 184.3 vs 175.6 ml, $p = 0.033$), and one DVC-SSL versus zero SL-DVC were transfused ($p = 0.442$). Overall (12.2% vs 12.0%, $p = 1.0$) and apical (1.3% vs 2.7%, $p = 0.361$) positive surgical margins were similar for DVC-SSL versus SL-DVC. Although 5-mo postoperative urinary function (mean: 72.9 vs 55.4, $p < 0.001$) and continence (61.4% vs 39.6%, $p < 0.001$) were better for DVC-SSL versus SL-DVC, 12-mo urinary outcomes were similar. In adjusted analyses, DVC-SSL versus SL-DVC was associated with shorter operative times (parameter estimate [PE] ± standard error [SE]: 16.84 ± 2.56, $p < 0.001$), and better 5-mo urinary function (PE ± SE: 19.93 ± 3.09, $p < 0.001$) and continence (odds ratio 3.39, 95% confidence interval 2.07–5.57, $p < 0.001$).

Conclusions: DVC-SSL versus SL-DVC improves early urinary control and shortens operative times due to fewer instrument changes with late versus early DVC control.

---

[1] Both authors contributed equally to share first authorship.

[*] Corresponding author. 75 Francis Street, Boston, MA 02015, USA. Tel. +1 617 732 4848; Fax: +1 617 566 3475.
E-mail address: jhu2@partners.org (J.C. Hu).

0302-2838/$ – see back matter © 2010 European Association of Urology. Published by Elsevier B.V. All rights reserved. doi:10.1016/j.eururo.2010.08.043

1. Introduction

While robot-assisted laparoscopic radical prostatectomy (RALP) has been rapidly adopted, questions remain concerning functional outcomes compared with open radical prostatectomy (RP). A recent population-based comparative effectiveness study of RALP versus RP demonstrated that RALP was associated with a greater likelihood of incontinence diagnosis [1]. However, the study design precluded assessing urinary function with self-reported quality of life instruments, and the >20-yr lead-time in diffusion of RP versus RALP must be considered when interpreting outcomes.

Although the RALP learning curve has been characterized to be 250–500 cases for attaining surgeon confidence and improved operative time and blood loss [2,3], the learning curve for preservation of urinary function remains poorly characterized. Although patient age, timing of postoperative assessment, definitions of incontinence, and method of data collection [4–7] affect urinary outcomes, surgical techniques to preserve the bladder neck, maximize membranous urethral length, and minimize damage to the rhabdosphincter improve continence [8–12].

The purpose of our study is to describe an efficient technique for athermal dorsal vein complex division followed by selective suture ligation (DVC-SSL) prior to RALP anastomosis and to compare outcomes with suture ligation prior to athermal DVC division (SL-DVC) prior to bladder-neck dissection.

2. Patients and methods

2.1. Enrollment

From September 2005 to July 2010, 865 men underwent RALP by a single surgeon (JCH). Our apical dissection technique evolved over time, and 231 RALP with endovascular stapler DVC ligation and division were excluded from analysis. Because bladder-neck preservation improves urinary control [8], and only 7 (2.8%) DVC-SSL versus 74 (19.6%) SL-DVC did not undergo bladder-neck preservation, there was an imbalance that precluded adjusting for bladder-neck preservation as a confounder. We therefore excluded 81 RALP without bladder-neck preservation. From February 2008 to April 2009, 303 men underwent SL-DVC after entry into the retropubic space prior to bladder-neck dissection. In May 2009, 10 men (excluded from analysis) underwent DVC skeletonization and ligation with Hem-o-Lok clips (Weck Surgical Instruments, Teleflex Medical, Durham, NC, USA) prior to anastomosis, and we observed that DVC venotomy bleeding was minimal with avoidance of assistant-surgeon suctioning and maintenance of pneumoperitoneum. We subsequently transitioned to DVC-SSL prior to anastomosis in 240 men.

2.2. Surgical technique

A Prograsp forceps, Maryland bipolar dissector, and curved monopolar scissors are inserted into the robotic fourth arm (medial to the left anterior superior iliac spine), and left and right arms, respectively. Energy settings are 25 W for both monopolar and bipolar currents, and monopolar current is only used for entry into the retropubic space and division of the posterior bladder-neck mucosa [8]. The CO_2 insufflation pressure and flow are set to 15 mm Hg and 10 l/min.

After entering the retropubic space of Retzius through either a transperitoneal or extraperitoneal approach, our original sequence for RALP was: 1) apical dissection and SL-DVC bladder-neck and seminal vesicle dissection; 2) posterior dissection of the prostate from the rectum; 3) ligation of the lateral pedicles with nerve sparing when indicated; and 4) anastomosis. However, our sequence and RALP apical dissection technique evolved, starting with bladder-neck dissection, shifting apical dissection and DVC-SSL to a later step prior to anastomosis, resulting in a completely antegrade approach.

2.2.1. Description of SL-DVC

The fourth robotic-arm Prograsp forceps (Intuitive Surgical Inc, Sunnyvale, CA, USA) creates cephalad tension while bunching the detrusor apron, aiding visualization of the anterolateral prostatic contour. In addition, a midprostatic suture is placed through the detrusor apron to prevent venous back-bleeding that occurs with DVC transection. Sharp and blunt dissection is performed to push the levator fascia (and underlying levator fibers) away from the prostatic apex until the puboprostatic ligaments are encountered anteriorly and exposure of the lateral aspect of the DVC is achieved (Fig. 1). The puboprostatic ligaments are partially divided and the Maryland dissector and curved scissors are switched out for robotic needle drivers, as SL-DVC is performed with a 2-0 Vicryl on a CT-1 needle (Ethicon, Cincinnati, OH, USA) in a figure-of-eight fashion (Fig. 2). After switching back to the Maryland dissector and scissors, the DVC and detrusor apron are sharply divided. The suture is replaced if inadvertently cut and/or loses tension and hemostasis during the subsequent apical dissection. The aforementioned original RALP dissection sequence is carried out.

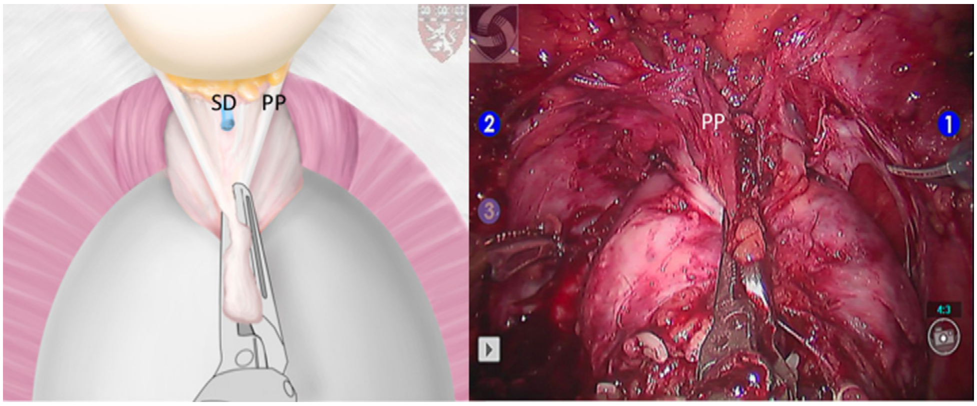


Fig. 1 – Anatomic landmarks prior to division of the dorsal vein complex. The superficial dorsal vein (SD) has been fulgrated with the Maryland bipolar. The levator muscles have been pushed off of the prostatic apex. The fourth arm Prograsp provides cephalad tension while bunching the detrusor apron, facilitating identification of the anterolateral prostatic contour and the puboprostatics (PP).

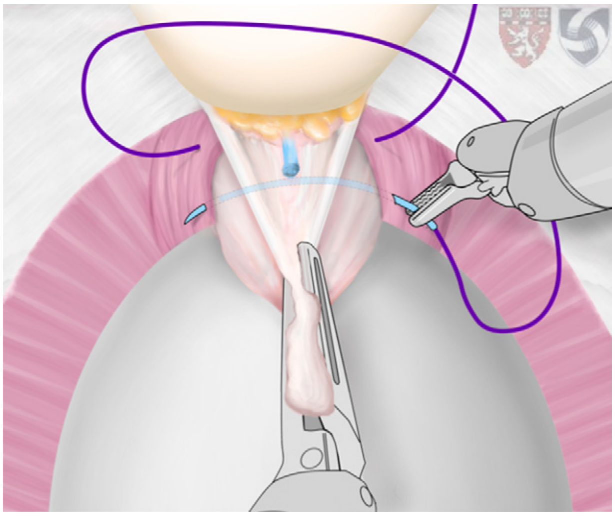


Fig. 2 – Standard technique for figure-of-eight suture ligation prior to division of dorsal vein complex.

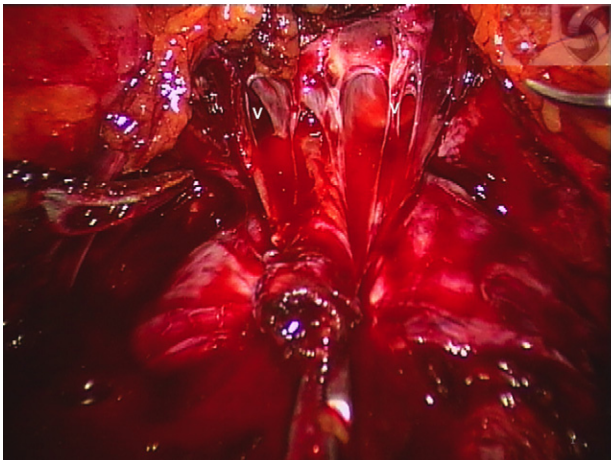


Fig. 4 – Athermal, sharp division of prominent dorsal vein complex components (v) prior to selective suture ligation.

2.2.2. *Description of DVC-SSL*

After nerve sparing, the fourth robotic-arm Prograsp forceps creates cephalad tension while bunching the detrusor apron, aiding visualization of the anterolateral prostatic contour (Fig. 1). Levator fibers are pushed away from the prostatic apex, and vascular structures between the detrusor apron and the apical prostate are divided sharply (Fig. 3). These include sinuses comprising the DVC (Fig. 4) and arterioles, which course within the detrusor apron anterior to the prostatic apex. Two arterioles are typically encountered medial to the venous sinuses and are controlled with pinpoint bipolar energy. The assistant surgeon suctions sparingly, primarily with the sucker tip submerged within a puddle of blood in order to prevent lowering of the pneumoperitoneum pressure to minimize venous bleeding. With DVC-SSL, use of a powerful suction apparatus that generates up to –500 mmHg (Stryker Neptune, Kalamazoo, MI, USA), in contrast to the –80 mmHg of conventional wall section, prevents clotting off the suction tip, hand piece, and/or tubing when clearing venous coagulum that may pool in the surgical field.

Blunt dissection is performed to identify a natural, avascular cleavage plane (Fig. 3) that extends sagitally from the detrusor apron pubic attachment to the prostate-urethral junction [13]. Once this cleavage plane is established anterior to the urethra, circumferential sharp and blunt dissection is performed to divide the ischioprostatic ligaments, or Walsh's "pillars" [14], until the prostate is completely freed with the exception of the urethral attachment. The fourth-arm Prograsp forceps grasping the prostate base is used to gently rotate the prostate, providing exposure to divide the remaining posterior rhabdosphincter attachments. Next, the anterior urethra is opened.

The robotic Maryland and curved scissors are switched out for needle drivers and selective suturing of DVC venotomies is performed followed by the anastomosis (Fig. 4). A 3-0 Vicryl cut to 23 cm on a CT-3 needle (Ethicon, Cincinnati, OH, USA) is used for both DVC-SSL and half of the anastomosis. This sequence minimizes instrument changes, and is the first and only robotic instrument exchange, as the anastomosis is performed immediately thereafter. The assistant then suctions the pneumoperitoneum to < 5 mmHg to identify bleeding from the venotomies, which are repaired with mattress sutures and thin bites to avoid trauma to the rhabdosphincter (Fig. 5). Typically, two to three venotomies are encountered. A posterior anastomotic suture is preplaced prior to division of the posterior urethra by the assistant's laparoscopic scissors (to avoid retraction of the urethral stump), avoiding an additional instrument change [2,15]. After the prostate is placed in the laparoscopic bag, the anastomosis is performed [15,16].

2.3. *Outcomes*

Urinary control was measured by Expanded Prostate Cancer Index Composite (EPIC) urinary function scores and by pad use. The EPIC

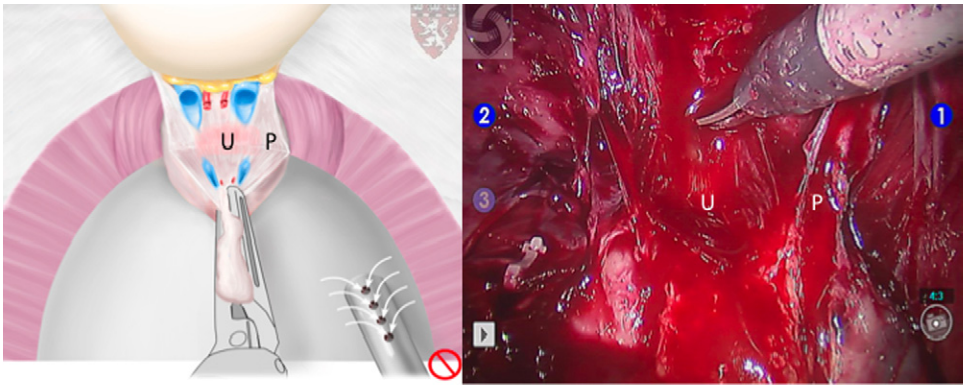


Fig. 3 – Vascular structures residing within the detrusor apron are sharply divided until blunt dissection is used to identify the avascular plane anterior to the urethra (U) and the pillars of Walsh (P) laterally. Arterioles are controlled with pinpoint bipolar energy set to 25W. Maintenance of pneumoperitoneum and avoidance of assistant suction allows visualization for dissection.

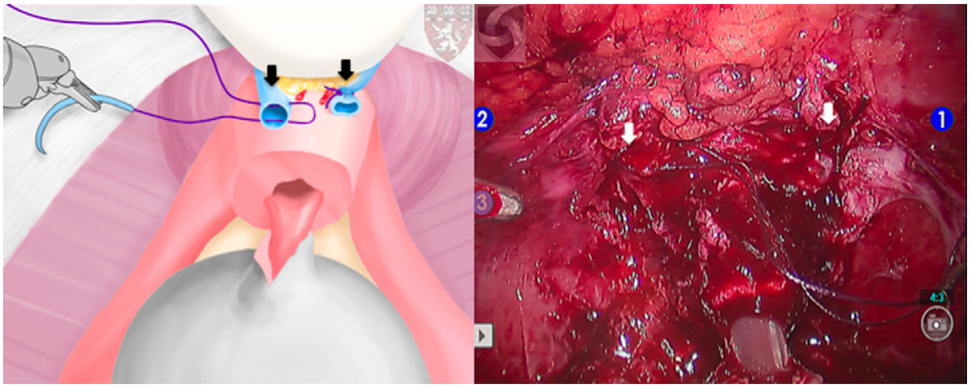


Fig. 5 – Selective mattress suture ligation of dorsal vein complex components (arrows) prior to anastomosis with a 22-cm 3-0 vicryl suture cut to 22 cm that is used for selective suturing and 50% of the anastomosis.

urinary function scale is scored continuously from 0 to 100, with higher scores representing better outcomes [17]. However, continence is commonly assessed by pad use, and we dichotomized responses to the corresponding EPIC item as no pads versus one pad or more per day. Three hundred and seventy eight men, 153 (58.9%) DVC-SSL versus 225 (74.3%) SL-DVC, were assessed at 5 mo postoperatively, and 275 men, 53 (73.6%) DVC-SSL versus 222 (73.5%) SL-DVC, were assessed at 12 mo postoperatively. We defined urine leak as drain-output creatinine greater than serum or contrast extravasation on cystography.

2.4. Statistical analysis

Data were prospectively collected and entered into an Access database (Microsoft, Redmond, WA, USA) by research personnel uninvolved with clinical care, and SAS v. 9.2 (SAS, Cary, NC, USA) was used for statistical analysis. The Wilcoxon rank-sum, chi-square, Fisher exact, and *t* tests were used for univariate and bivariate analyses. Stepwise logistic and linear regression models, with exclusion of covariates with $\alpha \geq 0.2$, were constructed to assess the change in apical dissection technique on operative time, blood loss, apical surgical margins, urinary function, and continence.

3. Results

3.1. Characteristics of the study population

Demographic and biopsy characteristics are demonstrated in Table 1. Men undergoing DVC-SSL versus SL-DVC were older (mean: 59.9 vs 57.8 yr, $p < 0.001$). The majority of men were white (92%), and race differed by apical dissection technique ($p < 0.001$). Furthermore, men undergoing DVC-SSL versus

Table 1 – Patient characteristics and preoperative pathologic data

	Division and selective suturing of dorsal vein complex $n = 240$	Non-selective suturing followed by division of dorsal vein complex $n = 303$	*p* value
Mean ± standard deviation			
Age, yr	59.9 ± 6.5	57.8 ± 6.7	<0.001
Body mass index, kg/m^2	29.2 ± 5.0	28.6 ± 4.9	0.090
Baseline urinary function score	96.7 ± 8.9	96.3 ± 10.8	0.727
PSA, ng/ml	5.7 ± 3.5	5.4 ± 2.8	0.172
No. (%)			
Race			
White	210 (87.5)	293 (96.7)	<0.001
Black	14 (5.8)	8 (2.6)	
Other	16 (6.7)	2 (0.7)	
Clinical stage			
T1c	226 (94.2)	287 (94.7)	0.090
T2a	8 (3.3)	15 (5)	
T2b	4 (1.7)	0	
T2c	2 (0.8)	1 (0.3)	
Gleason score			
3 + 2	0	3 (1)	0.001
3 + 3	111 (46.3)	192 (63.4)	
3 + 4	86 (35.8)	76 (25.1)	
4 + 3	29 (12.1)	22 (7.3)	
4 + 4	11 (4.6)	6 (2)	
3 + 5	0	2 (0.7)	
4 + 5	2 (0.8)	2 (0.7)	
5 + 4	1 (0.4)	0	

PSA = prostate-specific antigen.

SL-DVC were more likely to have higher biopsy Gleason scores: 53.7% versus 35.6% presented with Gleason ≥ 7 disease ($p = 0.001$). Prostate-specific antigen, clinical stage, body mass index (BMI), and baseline urinary function were similar by DVC surgical technique. Comparison of responder and nonresponders revealed no differences in demographics, baseline urinary function, or tumor characteristics (all $p > 0.05$).

Table 2 – Perioperative outcomes

	Division and selective suturing of dorsal vein complex $n = 240$	Non-selective suturing followed by division of dorsal vein complex $n = 303$	*p* value
Mean ± standard deviation			
Estimated blood loss, ml	184.3 ± 75.5	175.6 ± 85.6	0.033
Operative time, min	131.8 ± 18.3	147.0 ± 34.6	<0.001
Length of stay, d	1.1 ± 0.5	1.2 ± 0.8	0.662
Catheterization time, d[*]	8.4 ± 4.7	7.7 ± 2.5	0.110
Hematocrit change[**]	8.8 ± 3.4	8.9 ± 3.8	0.884
Bilateral nerve sparing, *n* (%)	194 (80.8)	219 (75.8)	0.268
Unilateral nerve sparing, *n* (%)	26 (10.8)	45 (15.6)	–
Non–nerve sparing, *n* (%)	20 (8.3)	25 (8.7)	–
Blood transfusion, *n* (%)	1 (0.4)	0	0.442
Cystogram leak rate[***], *n* (%)	8 (4.1)	10 (3.3)	0.640

[*] 14 men with missing nerve-sparing approach data.

[**] Difference between preoperative and postoperative day 1 hematocrit.

[***] 45 men were excluded from denominator when catheterization time and cystogram leak rate were calculated because these patients underwent a different anastomosis technique (barbed polyglyconate).

Table 3 – Pathologic outcome

	Division and selective suturing of dorsal vein complex $n = 240$	Nonselective suturing followed by division of dorsal vein complex $n = 303$	*p* value
Mean ± standard deviation			
Gland size, g	54.6 ± 17.7	54.2 ± 20.1	0.508
Tumor greatest dimension, cm	1.4 ± 0.7	1.3 ± 0.6	0.104
Pathologic stage, No. (%)			
T0	2 (0.8)	3 (1)	0.535
T2a	28 (11.7)	42 (13.9)	
T2b	11 (4.6)	6 (2)	
T2c	162 (67.5)	211 (69.9)	
T3a	28 (11.7)	29 (9.6)	
T3b	9 (3.8)	12 (4)	
Pathologic Gleason score, No. (%)			
3 + 2	1 (0.4)	0	<0.001
3 + 3	73 (30.7)	128 (42.7)	
3 + 4	94 (39.5)	124 (41.3)	
4 + 3	58 (24.4)	35 (11.7)	
4 + 4	5 (2.1)	8 (2.7)	
3 + 5	0	2 (0.7)	
4 + 5	6 (2.5)	3 (1)	
5 + 4	1 (0.4)	0	
Positive margin, No. (%)			
Apical	3 (1.3)	8 (2.7)	0.361
Overall	29 (12.2)	36 (12.0)	1.000

Table 4 – Comparison of patient self-reported postoperative recovery of urinary function and continence

	Sample size		Urinary function (mean ± standard deviation)			Continence[*]		
	DVC-SSL	SL-DVC	DVC-SSL	SL-DVC	*p* value	DVC-SSL (%)	SL-DVC (%)	*p* value
5 mo	153	225	72.9 ± 25.1	55.4 ± 30.9	<0.001	61.4	39.6	<0.001
12 mo	53	222	78.3 ± 23.0	77.0 ± 23.2	0.653	69.8	74.3	0.504

DVC-SSL = dorsal vein complex selective suture ligation; SL-DVC = dorsal vein complex suture ligation.

[*] Zero pads per day or pad free.

Table 5 – Multivariate analysis for urinary function, continence, and operative time

Covariate	Operative time			Urinary Function						Continence*							
				5 mo			12 mo			5 mo				12 mo			
	PE	SE	*p* value	PE	SE	*p* value	PE	SE	*p* value	OR	95% CI		*p* value	OR	95% CI		*p* value
DVC-SSL vs SL-DVC	−16.84	2.56	<0.001	19.93	3.09	<0.001	3.62	3.46	0.296	3.39	2.07	5.57	<0.001	1.01	0.49	2.08	0.986
Age	–	–	–	−0.85	0.23	<0.001	−0.42	0.22	0.055	0.94	0.90	0.97	<0.001	0.95	0.90	0.99	0.025
Baseline urinary function	–	–	–	0.55	0.16	<0.001	0.58	0.16	<0.001	1.03	1.00	1.06	0.049	1.04	1.01	1.08	0.005
Race (white vs nonwhite)	–	–	–	10.42	5.74	0.070	8.96	6.05	0.140	2.44	0.99	6.03	0.053	4.74	1.35	16.63	0.015
Body mass index	1.12	0.27	<0.001	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bilateral vs non–nerve sparing	−0.57	4.56	0.901	15.48	5.84	0.008	12.20	4.88	0.013	1.97	0.78	5.00	0.153	2.61	1.04	6.55	0.041
Unilateral vs non–nerve sparing	−7.77	5.52	0.160	17.91	6.62	0.007	9.39	5.58	0.094	2.27	0.79	6.48	0.127	1.51	0.53	4.30	0.439

PE = parameter estimate; SE = standard error; OR = odds ratio; CI = confidence interval; DVC-SSL = dorsal vein complex selective suture ligation; SL-DVC = dorsal vein complex suture ligation.

[*] Defined as zero pads per day or pad free.

3.2. *Perioperative outcomes*

Men undergoing DVC-SSL versus SL-DVC experienced shorter operative times (mean: 131 vs 147 min, $p < 0.001$). Men undergoing DVC-SSL versus SL-DVC experienced greater estimated blood loss, (mean: 184.3 vs 175.6 ml, $p = 0.033$); however, there was no difference in preoperative to postoperative day 1 hematocrit change. One DVC-SSL versus zero SL-DVC underwent blood transfusion ($p = 0.442$), and utilization of nerve-sparing technique and length of stay were similar. In addition, there were no differences in urine leaks and catheterization duration (Table 2).

Prostate size and tumor volume were similar by DVC dissection technique (Table 3). While pathologic stage was similar by DVC surgical technique, pathologic Gleason score mirrored biopsy findings, with men undergoing DVC-SSL versus SL-DVC more likely to have higher Gleason scores ($p < 0.001$). For example, 68.9% of DVC-SSL had pathologic Gleason scores of ≥ 7 versus 57.3% of SL-DVC. Similar to overall surgical margin positivity, there was no variation in apical margin positivity by DVC technique: Three (1.3%) DVC-SSL versus eight (2.7%) SL-DVC had an apical positive margin ($p = 0.361$).

3.3. *Urinary control*

Urinary function (mean: 72.9 vs 55.4, $p < 0.001$) and continence (61.4% vs 39.6%, $p < 0.001$) were better at 5 mo with DVC-SSL versus SL-DVC (Table 4); however, urinary function and continence were similar at 12 mo.

In adjusted analysis (Table 5), DVC-SSL versus SL-DVC was associated with better urinary function (parameter estimate [PE] ± standard error [SE]: 19.93 ± 3.09, $p < 0.001$) and continence (odds ratio: 3.39; 95% confidence interval: 2.07–5.57; $p < 0.001$) at 5 mo and shorter operative times (PE ± SE: -16.84 ± 2.56, $p < 0.001$). Conversely, higher BMI (PE ± SE: 1.12 ± 0.27, $p < 0.001$) was associated with longer operative times, but did not affect urinary function or continence. In addition, older age was associated with worse urinary function and continence, while better baseline urinary control was associated with improved postoperative urinary function and continence. In contrast to unadjusted analysis, DVC-SSL versus SL-DVC was not associated with increased blood loss in adjusted analyses.

4. Discussion

The precise etiology of postprostatectomy incontinence remains unknown. However, with the standard apical dissection technique SL-DVC, the suture may be placed too deeply, damaging the rhabdosphincter and underlying neurovascular components leading to incontinence [4]. Therefore, some have suggested that DVC-SSL should be performed after levator fibers have been bluntly dissected away from the prostate and the anterolateral aspects of the urethra, leading to hemostasis and rhabdosphincter preservation [11].

Our paper has several important findings. First, we present a parsimonious apical dissection technique and SSL-DVC without the use of monopolar cautery. With monopolar electrocautery, the patient is a part of the electrical circuit, and the path of the current may not correlate with anatomic distances [18]. The premise of our technique is sharp cold-scissor dissection of anatomic tissue planes rather than use of monopolar energy and resultant charring while creating surgical planes. Arterioles are controlled with bipolar energy, eliminating the patient from the electrical circuit. While the use of thermal energy is common and the prostate vascular pedicles may serve as a heat sink [19], a study of the use of energy in proximity to the periprostatic neurovascular bundle in canines demonstrated diminished erectile function [18].

While the RALP apical dissection and SL-DVC may be performed early, this may be associated with several disadvantages. First, in contrast to our antegrade RALP dissection sequence of bladder-neck dissection first and apical dissection prior to anastomosis, which requires only one robotic instrument change, several instrument changes are required with early SL-DVC, as there must be an exchange back to dissecting instruments for the bladder-neck and nerve sparing, followed by another switch to needle drivers for the anastomosis. For those operating with consistent operating-room personnel and a consistent bedside assistant, such as a physician's assistant or scrub technician/first assist, instrument changes are safe and efficient. However, in a training program, instrument changes may slow the flow of the case and pose hazards; we edited out 1 min in the accompanying video while switching to the right and left robotic needle drivers. Moreover, plugging in the energy source to the robotic scissors after it has been engaged or inserting the instrument beyond the point of robotic engagement may lead to iatrogenic injury. Performing the apical dissection just prior to anastomosis minimizes these concerns. Second, variation in venous anatomy and bleeding encountered with early SL-DVC may obscure anatomic planes for subsequent bladder-neck dissection, nerve sparing, etc., as tissue becomes blood stained. However, when DVC-SSL is performed prior to the anastomosis, the venous structures can be transected with impunity since blood will not saturate tissue planes that have already been dissected.

Second, our technique of DVC-SSL versus SL-DVC is associated with improved early urinary function and continence. However, there was no difference in 12-mo urinary function, continence, urine leaks, and catheterization duration. Our results are consistent with Porpiglia, who reported 3-mo continence rates of 80% versus 55% for laparoscopic radical prostatectomy with versus without selective suture ligation [12].

Third, while our DVC-SSL apical positive margin rate was less than half of the SL-DVC rate, this was not statistically significant. However, we may have been underpowered to detect a difference in this infrequent event. While Porpiglia reported similar apical margin positivity during laparoscopic radical prostatectomy when comparing DVC suturing techniques [12], Guru reported fewer positive apical margins with DVC-SSL [20].

Fourth, DVC-SSL prior to anastomosis shortened operative times by >15 min compared with early SL-DVC; however, because apical dissection sequence and technique modification occurred simultaneously, we are unable to assess the relative contributions to reduced operative time. Although this difference is less important clinically, the benefits of shorter operative time include less anesthesia and associated risks and reduced costs. Cost estimates for 1 min of operating room time range from US$13–20 [21,22]. Additionally, we found that higher BMI was associated with longer operative times, consistent with others [23].

Finally, in adjusted analysis, better urinary function and continence were associated with younger age, better baseline urinary function, and white race. Several studies have shown older age to be a risk factor for postoperative incontinence [24–26], which parallels anatomic studies demonstrating atrophy of the rhabdosphincter [27] and neural degeneration [28] with advancing age. In addition, Reynolds demonstrated that men who were leak and pad-free versus those with deficits at baseline were more likely to regain baseline continence levels 6 mo after RALP [29]. Moreover, Rice reported that black compared with white men were at greater risk of urinary function decline after treatment for prostate cancer, regardless of treatment choice [30].

Our findings must be interpreted in the context of the study design. First, many factors may affect postoperative urinary function, continence, operative time, blood loss, and apical positive margins, and we adjusted for observable characteristics such as age, baseline urinary function, nerve-sparing techniques, and BMI. However, this is a single-surgeon series, and others must corroborate our findings. Second, this was not a prospective randomized study, which may permit determination of the relative contribution of modifications to reducing operative time. However, this is difficult to conduct with single-surgeon series. With technique modifications, surgeons may develop bias and habits that preclude reversion to a prior technique. For instance, without analysis, we subjectively observed technical advantages that biased against reversion to SL-DVC: 1) DVC-SSL precludes replacing a suture that may be cut out with SL-DVC or dissecting more proximally to avoid cutting out the SL-DVC suture, which may increase apical-margin positivity; 2) the reduced operative time and lower risk of iatrogenic injury due to one DVC-SSL instrument change. However, our data were collected prospectively and the study was performed over a short interim beyond 300 initial cases after fellowship training, minimizing learning curve effects. Third, we incurred loss to follow-up despite attempts to telephone nonresponders; however, this is inevitable with travel to referral centers. Additionally, comparison of responder versus nonresponder characteristics did not yield significant differences. Finally, we may have been underpowered to detect differences in apical-margin positivity and 12-mo urinary control.

5. Conclusions

DVC-SSL versus SL-DVC is associated with improved early urinary control and shorter operative times.

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: Lei, Alemozaffar, Williams, Plaster, Amarasekera, Ulmer, Huang, Kowalczyk, Hu.
Analysis and interpretation of data: Hevelone, Lipsitz.
Drafting of the manuscript: Lei, Alemozaffar, Williams, Hu.
Critical revision of the manuscript for important intellectual content: Huang, Kowalczyk.
Statistical analysis: Hevelone, Lipsitz.
Obtaining funding: None.
Administrative, technical, or material support: None.
Supervision: Hu.
Other (specify)*:* None.

Financial disclosures: I certify that all conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript (eg, employment/ affiliation, grants or funding, consultancies, honoraria, stock ownership or options, expert testimony, royalties, or patents filed, received, or pending), are the following: None.

Funding/Support and role of the sponsor: None.

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.2010.08.043 and via www.europeanurology.com.

References

[1] Hu JC, Gu X, Lipsitz SR, et al. Comparative effectiveness of minimally invasive vs open radical prostatectomy. JAMA 2009;302:1557–64.

[2] Freire MP, Choi WW, Lei Y, Carvas F, Hu JC. Overcoming the learning curve for robotic-assisted laparoscopic radical prostatectomy. Urol Clin North Am 2010;37:37–47.

[3] Herrell SD, Smith Jr JA. Robotic-assisted laparoscopic prostatectomy: what is the learning curve? Urology 2005;66:105–7.

[4] Carlson KV, Nitti VW. Prevention and management of incontinence following radical prostatectomy. Urol Clin North Am 2001;28: 595–612.

[5] Glickman L, Godoy G, Lepor H. Changes in continence and erectile function between 2 and 4 years after radical prostatectomy. J Urol 2009;181:731–5.

[6] Loughlin KR, Prasad MM. Post-prostatectomy urinary incontinence: a confluence of 3 factors. J Urol 2010;183:871–7.

[7] Liss MA, Osann K, Canvasser N, et al. Continence definition after radical prostatectomy using urinary quality of life: evaluation of patient reported validated questionnaires. J Urol 2010;183:1464–8.

[8] Freire MP, Weinberg AC, Lei Y, et al. Anatomic bladder neck preservation during robotic-assisted laparoscopic radical prostatectomy: description of technique and outcomes. Eur Urol 2009;56: 972–80.

[9] Selli C, De Antoni P, Moro U, Macchiarella A, Giannarini G, Crisci A. Role of bladder neck preservation in urinary continence following radical retropubic prostatectomy. Scand J Urol Nephrol 2004;38: 32–37.

[10] Paparel P, Akin O, Sandhu JS, et al. Recovery of urinary continence after radical prostatectomy: association with urethral length and urethral fibrosis measured by preoperative and postoperative endorectal magnetic resonance imaging. Eur Urol 2009;55: 629–39.

[11] Menon M, Shrivastava A, Kaul S, et al. Vattikuti Institute prostatectomy: contemporary technique and analysis of results. Eur Urol 2007;51:648–58.

[12] Porpiglia F, Fiori C, Grande S, Morra I, Scarpa RM. Selective versus standard ligature of the deep venous complex during laparoscopic radical prostatectomy: effects on continence, blood loss, and margin status. Eur Urol 2009;55:1377–85.

[13] Myers RP. Detrusor apron, associated vascular plexus, and avascular plane: relevance to radical retropubic prostatectomy–anatomic and surgical commentary. Urology 2002;59:472–9.

[14] Myers RP. Practical surgical anatomy for radical prostatectomy. Urol Clin North Am 2001;28:473–90.

[15] Williams SB, Alemozaffar M, Lei Y, et al. Randomized controlled trial of barbed polyglyconate versus polyglactin suture for robot-assisted laparoscopic prostatectomy anastomosis: description of technique and outcomes. Eur Urol. In press. DOI: 10.1016/j.eururo.2010.07.021.

[16] Berry AM, Korkes F, Ferreira M, Hu JC. Robotic urethrovesical anastomosis: combining running and interrupted sutures. J Endourol 2008;22:2127–9.

[17] Wei JT, Dunn RL, Litwin MS, Sandler HM, Sanda MG. Development and validation of the expanded prostate cancer index composite (EPIC) for comprehensive assessment of health-related quality of life in men with prostate cancer. Urology 2000;56:899–905.

[18] Ong AM, Su LM, Varkarakis I, et al. Nerve sparing radical prostatectomy: effects of hemostatic energy sources on the recovery of cavernous nerve function in a canine model. J Urol 2004;172: 1318–22.

[19] Khan F, Rodriguez E, Finley DS, Skarecky DW, Ahlering TE. Spread of thermal energy and heat sinks: implications for nerve-sparing robotic prostatectomy. J Endourol 2007;21:1195–8.

[20] Guru KA, Perlmutter AE, Sheldon MJ, et al. Apical margins after robot-assisted radical prostatectomy: does technique matter? J Endourol 2009;23:123–7.

[21] Bolenz C, Gupta A, Hotze T, et al. Cost comparison of robotic, laparoscopic, and open radical prostatectomy for prostate cancer. Eur Urol 2010;57:453–8.

[22] Macario A. What does one minute of operating room time cost? J Clin Anesth 2010;22:233–6.

[23] Boorjian SA, Crispen PL, Carlson RE, et al. Impact of obesity on clinicopathologic outcomes after robot-assisted laparoscopic prostatectomy. J Endourol 2008;22:1471–6.

[24] Sacco E, Prayer-Galetti T, Pinto F, et al. Urinary incontinence after radical prostatectomy: incidence by definition, risk factors and temporal trend in a large series with a long-term follow-up. BJU Int 2006;97:1234–41.

[25] Rogers CG, Su LM, Link RE, Sullivan W, Wagner A, Pavlovich CP. Age stratified functional outcomes after laparoscopic radical prostatectomy. J Urol 2006;176:2448–52.

[26] Gacci M, Simonato A, Masieri L, et al. Urinary and sexual outcomes in long-term (5+ years) prostate cancer disease free survivors after radical prostatectomy. Health Qual Life Outcomes 2009; 7:94.

[27] Burnett AL, Mostwin JL. In situ anatomical study of the male urethral sphincteric complex: relevance to continence preservation following major pelvic surgery. J Urol 1998;160:1301–6.

[28] Hollabaugh Jr RS, Dmochowski RR, Kneib TG, Steiner MS. Preservation of putative continence nerves during radical retropubic prostatectomy leads to more rapid return of urinary continence. Urology 1998;51:960–7.

[29] Reynolds WS, Shikanov SA, Katz MH, Zagaja GP, Shalhav AL, Zorn KC. Analysis of continence rates following robot-assisted radical prostatectomy: strict leak-free and pad-free continence. Urology 2010;75:431–6.

[30] Rice K, Hudak J, Peay K, et al. Comprehensive quality-of-life outcomes in the setting of a multidisciplinary, equal access prostate cancer clinic. Urology 2010;76:1231–8.

EUROPEAN UROLOGY 59 (2011) 595–603

available at www.sciencedirect.com
journal homepage: www.europeanurology.com

European Association of Urology

Surgery in Motion

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

Andy C. Huang [a,1], *Keith J. Kowalczyk* [a,1], *Nathanael D. Hevelone* [b], *Stuart R. Lipsitz* [b], *Hua-yin Yu* [a], *Blakely A. Plaster* [a], *Channa A. Amarasekara* [a], *William D. Ulmer* [a], *Yin Lei* [a], *Stephen B. Williams* [a], *Jim C. Hu* [a,b,*]

[a] *Division of Urologic Surgery, Brigham and Women's/Faulkner Hospital, Harvard Medical School, Boston, MA, USA*
[b] *Center for Surgery and Public Health, Brigham and Women's/Faulkner Hospital, Harvard Medical School, Boston, MA, USA*

Article info

Article history:
Accepted January 18, 2011
Published online ahead of print on January 27, 2011

Keywords:
Robot-assisted surgery
Radical prostatectomy
Benign prostatic hyperplasia
Outcomes
Prostate cancer

Please visit www.europeanurology.com and www.urosource.com to view the accompanying video.

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.

---

[1] Both authors contributed equally and share the first authorship.

[*] Corresponding author. Brigham and Women's/Faulkner Hospital, 1153 Centre Street, Suite 4420, Boston, MA 02130, USA. Tel. +1 617 983 4570; Fax: +1 617 983 7945.
E-mail address: jhu2@partners.org (J.C. Hu).

0302-2838/$ – see back matter © 2011 European Association of Urology. Published by Elsevier B.V. All rights reserved. doi:10.1016/j.eururo.2011.01.033

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.

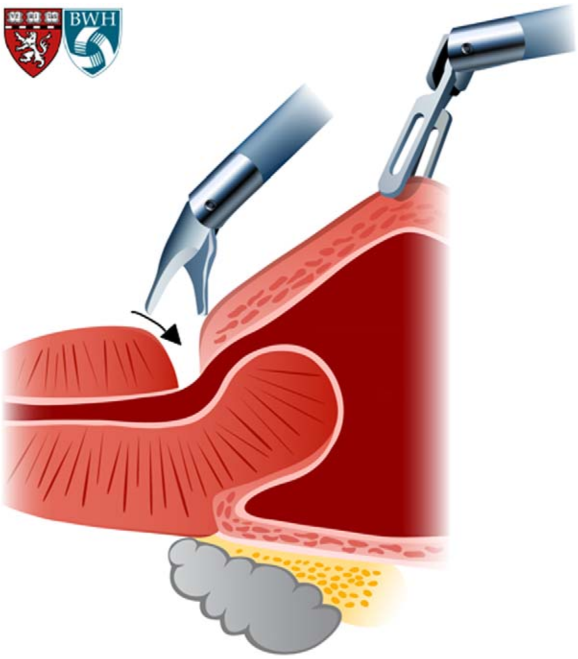


Fig. 1 – The fourth arm tents up the bladder for anterocephalad retraction, and the anterior bladder neck dissection is initiated where the bladder and detrusor apron tenting stops midprostate. Median lobes may attenuate the bladder wall anteriorly. Sharp dissection is used to identify longitudinal fibers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

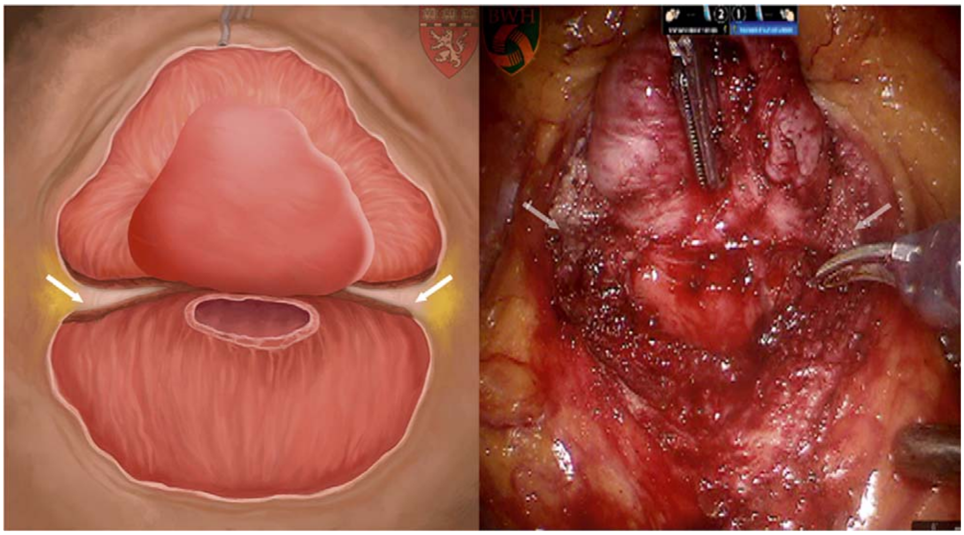


Fig. 2 – **Prior to bladder entry, bladder attachments are dissected off of the prostate until reaching the prostatovesical junction (arrows). Releasing these attachments posterolaterally until encountering the lateral pedicle fat pad minimizes subsequent tearing of the bladder neck; tearing may occur 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

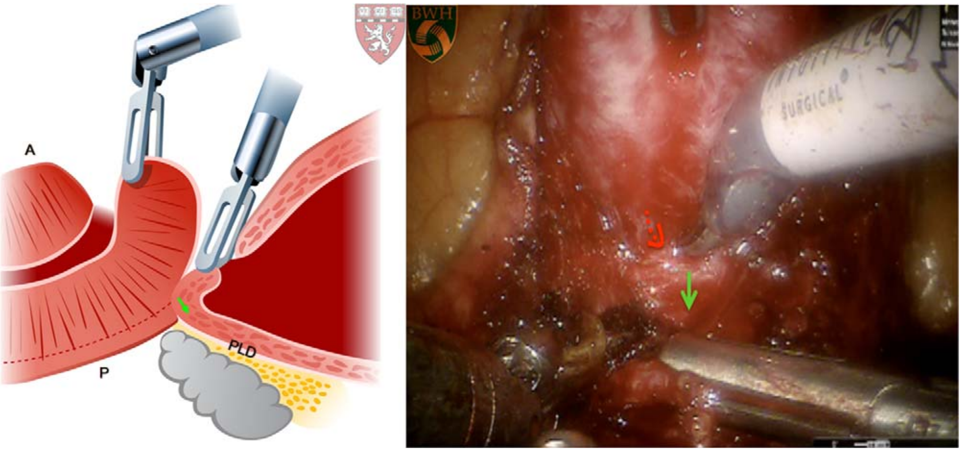


Fig. 3 – **Anterocaudal fourth-arm Prograsp tension is applied to the median lobe, while the assistant applies anterocephalad tension to the posterior bladder neck to identify the anatomic dissection plane. The assistant intermittently releases the posterior bladder neck to allow the surgeon to index 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 stricture	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 intervention, 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.
Drafting of the manuscript: Huang, Kowalczyk, Hevelone, Lipsitz, Yu, Williams, Hu.
Critical revision of the manuscript for important intellectual content: Huang, Kowalczyk, Hevelone, Lipsitz, Yu, Plaster, Amarasekara, Ulmer, Lei, Williams, Hu.

Statistical analysis: Hevelone, Lipsitz, Hu.
Obtaining funding: None.
Administrative, technical, or material support: Kowalczyk, Williams, Hu.
Supervision: Hu.
Other (specify): None.

Financial disclosures: I certify that all conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript (eg, employment/affiliation, grants or funding, consultancies, honoraria, stock ownership or options, expert testimony, royalties, or patents filed, received, or pending), are the following: None.

Funding/Support and role of the sponsor: This research was funded by the Robert and Kathy Salipante Minimally Invasive Urologic Research Fellowship (K.J.K.), the Tapei City Hospital Research Fellowship (A.C.H.), the American Urologic Association Foundation Research Fellowship (H.Y.), the American Urologic Association Herbert Brendler Summer Medical Student Research Fellowship Award (W.D.U.), the New York Academy of Medicine David E. Rogers Fellowship (W.D.U.), and the US Department of Defense Prostate Cancer Physician Training Award W81XWH-08-1-0283 (J.C.H.).

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.

References

[1] Feneley M, Landis P, Simon I, et al. Today men with prostate cancer have larger prostates. Urology 2000;56:839–42.
[2] Zelefsky MJ, Ginor RX, Fuks Z, Leibel SA. Efficacy of selective alpha-1 blocker therapy in the treatment of acute urinary symptoms during radiotherapy for localized prostate cancer. Int J Radiat Oncol Biol Phys 1999;45:567–70.
[3] Crook J, McLean M, Catton C, Yeung I, Tsihlias J, Pintilie M. Factors influencing risk of acute urinary retention after TRUS-guided permanent prostate seed implantation. Int J Radiat Oncol Biol Phys 2002;52:453–60.
[4] Chan R, Barocas D, Chang S, et al. Effect of a large prostate gland on open and robotically assisted laparoscopic radical prostatectomy. BJU Int 2008;101:1140–4.
[5] Zorn K, Orvieto M, Mikhail A, et al. Effect of prostate weight on operative and postoperative outcomes of robotic-assisted laparoscopic prostatectomy. Urology 2007;69:300–5.
[6] Skolarus T, Hedgepeth R, Zhang Y, et al. Does robotic technology mitigate the challenges of large prostate size? Urology 2010;76:1117–21.
[7] Link B, Nelson R, Josephson D, et al. The impact of prostate gland weight in robot assisted laparoscopic radical prostatectomy. J Urol 2008;180:928–32.
[8] Meeks J, Zhao L, Greco K, Macejko A, Nadler R. Impact of prostate median lobe anatomy on robotic-assisted laparoscopic prostatectomy. Urology 2009;73:323–7.
[9] Ellis WJ, Lange PH. Point: open radical prostatectomy should not be abandoned. J Natl Compr Cancer Network 2007;5:685–8.
[10] Hampton L, Nelson R, Satterthwaite R, Wilson T, Crocitto L. Patients with prior TURP undergoing robot-assisted laparoscopic radical prostatectomy have higher positive surgical margin rates. J Robotic Surg 2008;2:213–6.
[11] Jaffe J, Stakhovsky O, Cathelineau X, Barret E, Vallancien G, Rozet F. Surgical outcomes for men undergoing laparoscopic radical prostatectomy after transurethral resection of the prostate. J Urol 2007;178:483–7.
[12] Palisaar J, Wenske S, Sommerer F, Hinkel A, Noldus J. Open radical retropubic prostatectomy gives favourable surgical and functional outcomes after transurethral resection of the prostate. BJU Int 2009;104:611–5.
[13] Herrell SD, Smith Jr JA. Robotic-assisted laparoscopic prostatectomy: what is the learning curve? Urology 2005;66(Suppl 5):105–7.
[14] Freire M, Choi W, Lei Y, Carvas F, Hu J. Overcoming the learning curve for robotic-assisted laparoscopic radical prostatectomy. Urol Clin North Am 2010;37:37–47.
[15] Freire MP, Weinberg AC, Lei Y, et al. Anatomic bladder neck preservation during robotic-assisted laparoscopic radical prostatectomy: description of technique and outcomes. Eur Urol 2009;56:972–80.
[16] Berry A, Korkes F, Hu J. Landmarks for consistent nerve sparing during robotic-assisted laparoscopic radical prostatectomy. J Endourol 2008;22:1565–8.
[17] Lei Y, Alemozaffar M, Williams SB, et al. Athermal division and selective suture ligation of the dorsal vein complex during robot-assisted laparoscopic radical prostatectomy: description of technique and outcomes. Eur Urol 2011;59:235–43.
[18] Berry A, Korkes F, Ferreira M, Hu J. Robotic urethrovesical anastomosis: combining running and interrupted sutures. J Endourol 2008;22:2127–30.
[19] Williams SB, Alemozaffar M, Lei Y, et al. Randomized controlled trial of barbed polyglyconate versus polyglactin suture for robot-assisted laparoscopic prostatectomy anastomosis: technique and outcomes. Eur Urol 2010;58:875–81.
[20] Patel S, Kaplon D, Jarrard D. A technique for the management of a large median lobe in robot-assisted laparoscopic radical prostatectomy. J Endourol 2010;24:92–4.
[21] Wei J, Dunn R, Litwin M, Sandler H, Sanda M. Development and validation of the Expanded Prostate Cancer Index Composite (EPIC) for comprehensive assessment of health-related quality of life in men with prostate cancer. Urology 2000;56:899–905.
[22] Schwartz B, Norbeck J, Hansberry K, Wettlaufer J, Thrasher J. The role of cystoscopy before radical prostatectomy. Br J Urol 1996;77:93–5.
[23] Colombo R, Naspro R, Salonia A, et al. Radical prostatectomy after previous prostate surgery: clinical and functional outcomes. J Urol 2006;176:2459–63.
[24] D'Amico A, Whittington R, Malkowicz S, Schultz D, Tomaszewski J, Wein A. A prostate gland volume of more than 75 cm^3 predicts for a favorable outcome after radical prostatectomy for localized prostate cancer. Urology 1998;52:631–6.
[25] Foley C, Bott S, Thomas K, Parkinson M, Kirby R. A large prostate at radical retropubic prostatectomy does not adversely affect cancer control, continence or potency rates. BJU Int 2003;92:370–4.
[26] Levinson A, Bagga H, Pavlovich C, et al. The impact of prostate size on urinary quality of life indexes following laparoscopic radical prostatectomy. J Urol 2008;179:1818–22.
[27] Hollenbeck B, Dunn R, Wei J, Montie J, Sanda M. Determinants of long-term sexual health outcome after radical prostatectomy measured by a validated instrument. J Urol 2003;169:1453–7.
[28] Jenkins L, Nogueira M, Wilding G, et al. Median lobe in robot-assisted radical prostatectomy: evaluation and management. Urology 2008;71:810–3.
[29] El-Hakim A, Leung RA, Richstone L, Kim TS, Te AE, Tewari AK. Athermal robotic technique of prostatectomy in patients with large prostate glands (>75 g): technique and initial results. BJU Int 2006;98:47–9.

EUROPEAN UROLOGY 60 (2011) 536–547

available at www.sciencedirect.com
journal homepage: www.europeanurology.com

European Association of Urology

Surgery in Motion

Stepwise Approach for Nerve Sparing Without Countertraction During Robot-Assisted Radical Prostatectomy: Technique and Outcomes

Keith J. Kowalczyk[a], *Andy C. Huang*[a], *Nathanael D. Hevelone*[b], *Stuart R. Lipsitz*[b], *Hua-yin Yu*[a], *William D. Ulmer*[a], *Joshua R. Kaplan*[a], *Sunil Patel*[a], *Paul L. Nguyen*[c], *Jim C. Hu*[a,b,*]

[a] *Division of Urologic Surgery, Brigham and Women's/Faulkner Hospital, Harvard Medical School, Boston, MA, USA*
[b] *Center for Surgery and Public Health, Brigham and Women's/Faulkner Hospital, Harvard Medical School, Boston, MA, USA*
[c] *Department of Radiation Oncology, Lank Center for Genitourinary Oncology, Dana Farber Cancer Institute, Boston, MA, USA*

Article info

Article history:
Accepted May 2, 2011
Published online ahead of print on May 17, 2011

Keywords:
Robot-assisted surgery
Nerve-sparing radical prostatectomy
Outcomes
Prostate cancer

Please visit www.europeanurology.com and www.urosource.com to view the accompanying video.

Abstract

Background: Although subtle technical variation affects potency preservation during robot-assisted laparoscopic radical prostatectomy (RARP), most prostatectomy studies focus on achieving the optimal anatomic nerve-sparing dissection plane. However, the impact of active assistant/surgeon neurovascular bundle (NVB) countertraction on sexual function outcomes has not been studied or quantified.

Objective: To illustrate technique and compare sexual function outcomes for nerve sparing without (NS-0C) versus with (NS-C) assistant and/or surgeon NVB countertraction.

Design, setting, and participants: This is a retrospective study of 342 NS-0C versus 268 NS-C RARP procedures performed between August 2008 and February 2011.

Surgical procedure: RARP.

Measurements: We used the Expanded Prostate Cancer Index Composite (EPIC) sexual function and potency scores, estimated blood loss (EBL), operative time, and positive surgical margin (PSM).

Results and limitations: In unadjusted analysis, men undergoing NS-0C versus NS-C were older, had worse baseline sexual function, higher biopsy and pathologic Gleason grade, and higher preoperative prostate-specific antigen (PSA) levels (all $p \leq 0.023$). However, NS-0C versus NS-C was associated with higher 5-mo sexual function scores (20 vs 10; $p < 0.001$), and this difference was accentuated for bilateral intrafascial nerve sparing in preoperatively potent men (35.8 vs 16.6; $p < 0.001$). Similarly, 5-mo potency for preoperatively potent men was better with bilateral intrafascial NS-0C versus NS-C (45.0% vs 28.4%; $p = 0.039$). However, no difference in sexual function or potency was observed at 12 mo. In adjusted analyses, NS-0C versus NS-C was associated with improved 5-mo sexual function (parameter estimate: 10.90; standard error: 2.16; $p < 0.001$) and potency (odds ratio: 1.69; 95% confidence interval, 1.01–2.83; $p = 0.046$). NS-0C versus NS-WC was associated with shorter operative times ($p = 0.001$) and higher EBL ($p = 0.001$); however, there were no significant differences in PSM. Limitations include the retrospective, single-surgeon study design and smaller numbers for 12-mo comparison.

Conclusions: Reliance on countertraction to facilitate dissecting NVB away from the prostate leads to neuropraxia and delayed recovery of sexual function and potency. Subtle technical modification to dissect the prostate away from the NVB without countertraction enables earlier return of sexual function and potency.

---

* Corresponding author. Brigham and Women's/Faulkner Hospital, 1153 Centre Street, Suite 4420, Boston, MA 02130, USA. Tel. +1 617 983 4570; Fax: +1 617 983 7945.
E-mail address: jhu2@partners.org (J.C. Hu).

0302-2838/$ – see back matter © 2011 European Association of Urology. Published by Elsevier B.V. All rights reserved. doi:10.1016/j.eururo.2011.05.001

1. Introduction

Walsh's anatomic description of the neurovascular bundle (NVB) and technique for preservation during retropubic radical prostatectomy (RRP) reduced morbidity and contributed to the displacement of radiation therapy (RT) as the most popular treatment for prostate cancer [1]. Presently in the United States, robot-assisted laparoscopic radical prostatectomy (RARP) has supplanted open radical prostatectomy (ORP) in popularity and is associated with fewer transfusions, fewer anastomotic strictures, and shorter lengths of stay [2]. However, published RARP sexual function outcomes are largely physician reported and typically much better than patient self-report with validated quality of life (QoL) instruments, and marketing unrealistic outcomes may heighten expectations and contribute to patient dissatisfaction and regret following RARP [3].

Variation in definitions of *potency,* exclusion criteria, and use of physician- versus patient-reported outcomes with validated QoL instruments contribute to challenges in interpreting and improving radical prostatectomy (RP) outcomes [4]. Moreover, heterogeneity in surgeon training and technique contribute to variation in postprostatectomy sexual function [5]. Although terminology such as *bilateral, unilateral, intrafascial,* and *interfascial nerve sparing* as well as *extrafascial* or *non–nerve sparing* appear ubiquitously in the RP literature, these terms may hold different meanings from surgeon to surgeon. Intraoperative video illustrates the nuances of broad technical terms, and review improves RP technique and outcomes [6,7] and may shorten the RARP learning curve by dissemination of surgical technique. The purpose of our study is to illustrate stepwise maneuvers for nerve sparing and compare outcomes associated with subtle variation in attenuating tension on the NVB during RARP nerve-sparing technique.

2. Methods and patients

2.1. Enrollment

From August 2005 through February 2011, 1023 consecutive RARP procedures were performed by a single surgeon (JCH) at Brigham and Women's/Faulkner Hospital; however, intraoperative video review revealed that consistent intra- and interfascial nerve-sparing dissection was not achieved until August 2008. In August 2009, our technique was modified to deliberately avoid assistant and surgeon countertraction on the NVB after an invitation to observe a Patrick Walsh RRP. Outcomes of 268 men undergoing nerve sparing with countertraction (NS-C) from August 2008 to August 2009 were retrospectively compared to 342 men undergoing nerve sparing without countertraction (NS-0C) from August 2009 to February 2011 after our technique change. Data were collected prospectively by research personnel uninvolved with clinical care and entered into an institutional review board–approved Microsoft Office Access database. Thirty-nine men received postoperative RT and/or hormone therapy and were excluded from analysis of sexual function recovery. The response rates at 5 and 12 mo were 83.1% and 70.8%, with 10.2% and 22.7% of subjects reached by telephone, respectively. One hundred twenty-two men responded outside of the 5- and 12-mo windows. There were no differences in responder and nonresponder demographics, tumor characteristics, or baseline Expanded Prostate Cancer Index Composite (EPIC) scores.

2.2. Surgical technique: bipolar, cut, and peel seminal vesicle dissection technique

An antegrade approach to RARP is performed as previously described [8–13]. After anatomic bladder neck preservation and division of the posterior longitudinal detrusor fibers, the vas deferens and seminal vesicles (SV) are identified, nestled within a varying amount of adipose tissue. The fourth-arm ProGrasp forceps (Intuitive Surgical, Sunnyvale, CA, USA) is applied distal to the ejaculatory duct to provide anterior traction, and the vas are clipped with a 10-mm Hem-o-lok clip (Teleex Medical, Durham, NC, USA). Prior to sharp division of the vas, assistant laparoscopic grasper countertraction is applied below the clip, in the direction of the assistant trocar. The artery of the vas typically courses between the vas and the medial aspect of the SV and is controlled by either inclusion with the aforementioned clip or with bipolar cautery at 25 W. Assistant counterclockwise rotation on the proximal vas stump improves subsequent exposure for SV dissection. The fourth arm is then applied to the SV to provide anterior traction, while blunt dissection is used to define the medial SV contour, which is typically avascular.

The SV dissection then proceeds laterally. SV arterial blood supply originates inferolaterally, and bipolar cautery is used sparingly to control arterioles located on the SV surface proximal to the SV tip (Fig. 1). After sharp division, the arterioles are gently peeled downward and away from the SV tip (Fig. 2). A potential pitfall is superfluous dissection of the SV to its prostate origin—particularly on the lateral aspect—as this results in potential bleeding and capsular incision. Moreover, this dissection is

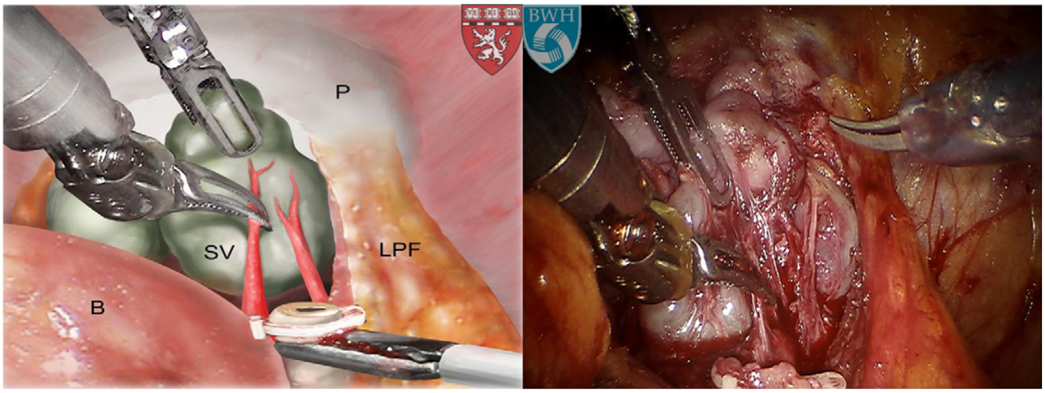


Fig. 1 – Fourth-arm ProGrasp anterior traction and assistant laparoscopic grasper countertraction facilitate the high isolation of arterioles proximal to the seminal vesicle tip.
P = prostate; SV = seminal vesicle; B = bladder; LPF = lateral pedicle fat.

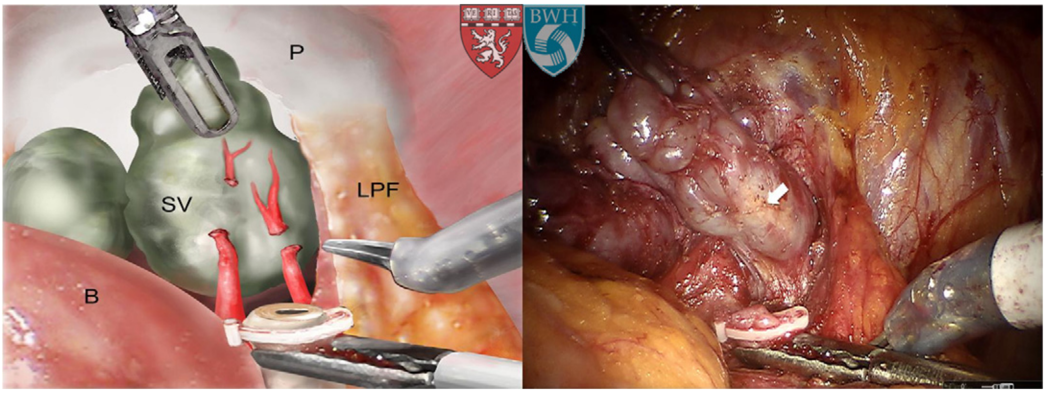


Fig. 2 – Bipolar 25-W current fulguration of arterioles prior to cut-and-peel technique to divide and bluntly sweep arterioles beyond the seminal vesicle (SV) tip. The white arrow indicates bipolar char proximal to the SV tip.
P = prostate; SV = seminal vesicle; B = bladder; LPF = lateral pedicle fat.

accomplished with subsequent ligation and division of the lateral pedicle. After bilateral SV dissection, the fourth-arm ProGrasp forceps retracts both SVs superiorly to provide exposure for the posterior dissection.

2.2.1. Posterior dissection and development of the posterior prostatic contour

After sharply incising Denonvillier's fascia in the midline, the anatomic plane between the prostatic fascia (PF) and Denonvillier's fascia is separated for intrafascial nerve sparing, thus defining the posterior prostatic contour (Fig. 3) [10]. During interfascial dissection for high-volume intermediate- or high-risk disease, the posterior dissection plane is deeper, separating prerectal fat from Denonvillier's fascia, which is left on the posterior prostate. Following the posterior contour distally, the dissection plane is developed toward the apex, and then laterally until encountering veins that run from apex to base that landmark the medial NVB border. Greater prostate volume hinders visualization and limits the extent of dissection, and subsequent rotation of the prostate must be performed during the apical dissection to complete the posterior dissection [13].

2.2.2. Periprostatic fascia separation and development of the anterior prostatic contour

Our preference is to start with right nerve sparing because of better working angles with the robotic scissors entering from right of midline. After releasing right-sided attachments and attaining resultant prostate mobility, left nerve sparing follows. At the right midprostate, a "prostatic rub" is employed medial to the fascial tendinous arch [10] to split the periprostatic fascia, lateralizing the levator fascia (LF) to cover the levator ani fibers and defining the anterolateral prostate contour, covered by outer PF (Fig. 4 and 5). Moreover, nerves running along the medial border of the LF are pushed posterolaterally using blunt dissection. Rubbing toward the prostate base defines the distal fold of the lateral pedicle. In men with finer or more translucent PF, fibroadipose tissue may be seen underlying the outer PF (Fig. 5). The junction between the medial edge of the fibroadipose tissue and the prostate capsule defines the intrafascial dissection plane. Alternatively, in men with thicker PF, incision of the outer PF allows identification of this medial edge of the NVB; however, we do not incise routinely, particularly when confronted with prominent or multiple capsular veins coursing below the outer PF. If these veins are inadvertently punctured, maintenance of pneumoperitoneum often results in thrombosis and control [12]. However, prominent venous bleeding is controlled with clips, avoiding instrument change to needle drivers for suture ligation.

2.2.3. Division of the lateral vascular pedicles

The confluence of the anterior and posterior prostate contours and distal fold of the lateral pedicle serve as landmarks for lateral vascular pedicle ligation (Fig. 6) [10]. Hem-o-lok clips are placed on both the specimen (to

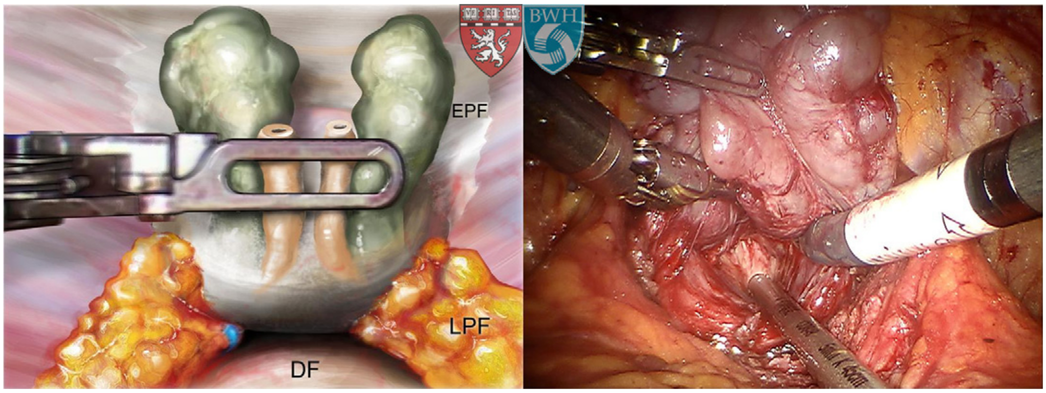


Fig. 3 – After seminal vesicle dissection and prior to defining the anterior prostate contour (endopelvic fascia intact), the posterior dissection is performed. Denonvillier's fascia is separated posteriorly from the prostatic fascia in the midline, and the posterior prostate contour is defined. The dissection is carried out lateral to the lateral pedicle fat pad proximally. Distally, veins that provide the landmark of the medial border of the neurovascular bundle are commonly encountered at the mid- and apical prostate and serve as the lateral border of the dissection.
EPF = endopelvic fascia; DF = Denonvillier's fascia; LPF = lateral pedicle fat.

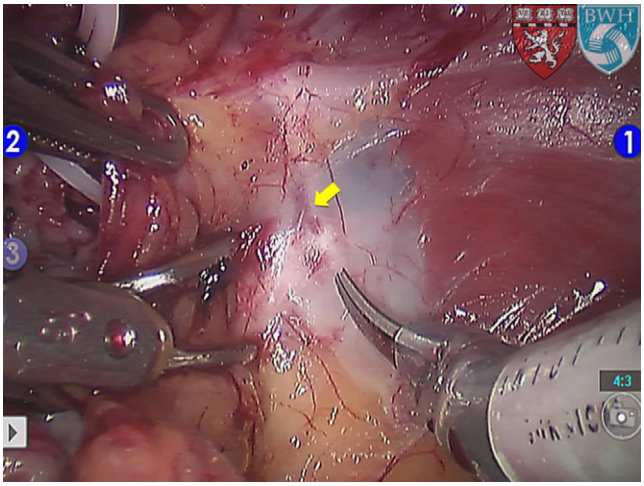


Fig. 4 – Prior to periprostatic fascia separation, the condensation of the prostatic and levator fascia may be visualized (between the arrow and the scissors tip) in men with thinner, more translucent fascial layers.

avoid back-bleeding, because the dorsal vein complex [DVC] has not been ligated) and stay side prior to sharp, cold scissor division. Clips are placed up to the distal lateral pedicle fold, beyond which intrafascial versus interfascial nerve sparing is executed (Fig. 7).

2.2.4. *Antegrade neurovascular bundle release*

For the intrafascial nerve-sparing plane, which is largely avascular distal to the lateral pedicle, the outer and inner PF (with NVB components located in between) are incised onto the prostatic capsule after lateral pedicle ligation and division. The intrafascial plane courses between the capsule and inner PF (Fig. 8), and a combination of sharp and blunt dissection are used to follow this plane. Moreover, intraoperative observation and video review demonstrate that venous components are commonly the most medial component of the NVB, as they are often seen lateral to inner PF during intrafascial nerve sparing. For interfascial nerve sparing, a layer of the periprostatic fibroadipose tissue is left overlying inner PF and prostate capsule, and more sharp dissection is used in comparison to intrafascial nerve sparing. Moreover, NVB veins may be landmarked and intentionally split, leaving the medial wall of the vein and underlying inner PF with the prostate (Fig. 9a and 9b). In addition, arterioles may be encountered and are controlled with 5-mm Hem-o-lok clips. Extrafascial dissection, or non–nerve sparing, is performed superficial to the outer PF in men with high-volume, high-risk disease characteristics.

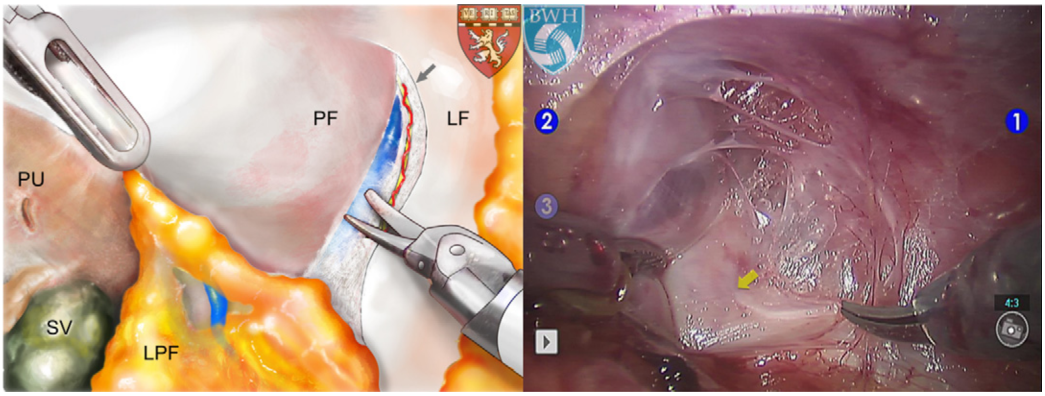


Fig. 5 – Prostatic rub used for periprostatic fascia separation. Nerve bundle components are encountered on the medial aspect of the levator fascia (LF) and pushed laterally. Arrows denote the leading edge of the LF. The outer prostatic fascia (PF) remains medially on the prostate distal to the lateral pedicle and the fat pad located posterolaterally between the bladder and the prostate. In thinner men with finer or more translucent PF, fibroadipose tissue may be seen underlying the outer PF.
PU = prostatic urethra; PF prostatic fascia; LF = levator fascia; SV = seminal vesicle; LPF = lateral pedicle fat.

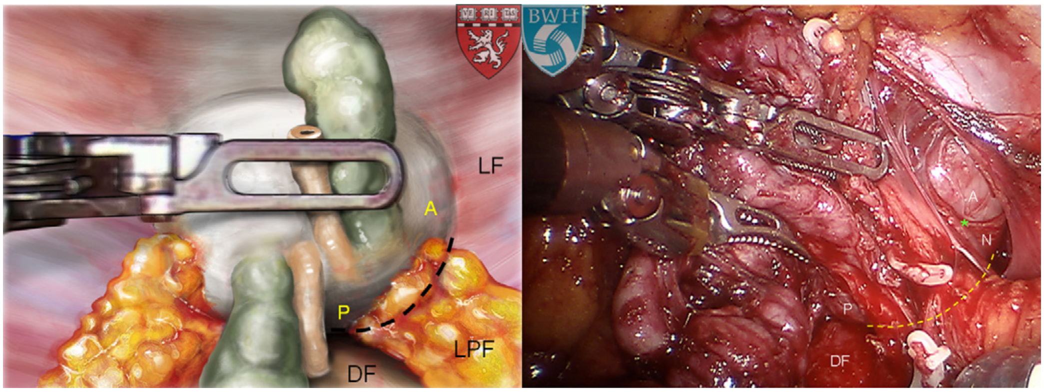


Fig. 6 – After division of the lateral pedicle fat pad, the confluence of the right anterior and posterior contours, denoted by the green asterisk, serves as a landmark for lateral pedicle ligation and division before antegrade nerve sparing. In addition, the medial neurovascular bundle edge is visible after incision of the outer prostatic fascia.
LF = levator fascia; A = anterior; P = posterior; DF = Denonvillier's fascia; LPF = lateral pedicle fat.

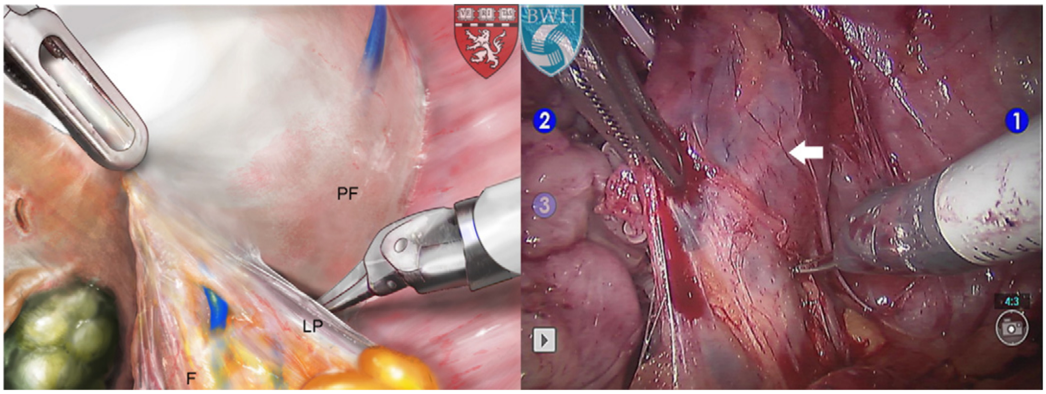


Fig. 7 – The robotic scissors are inserted at the confluence of contours and the distal fold of the lateral pedicle to create space for clip placement and ligation prior to division. The outer prostatic fascia has not been incised in this example; however, the medial edge of fibroadipose neurovascular bundle tissue (arrow) is identified just lateral to vein coursing on the prostate. Fat proximal to lateral pedicle (F).
PF = prostatic fascia; LP = lateral pedicle.

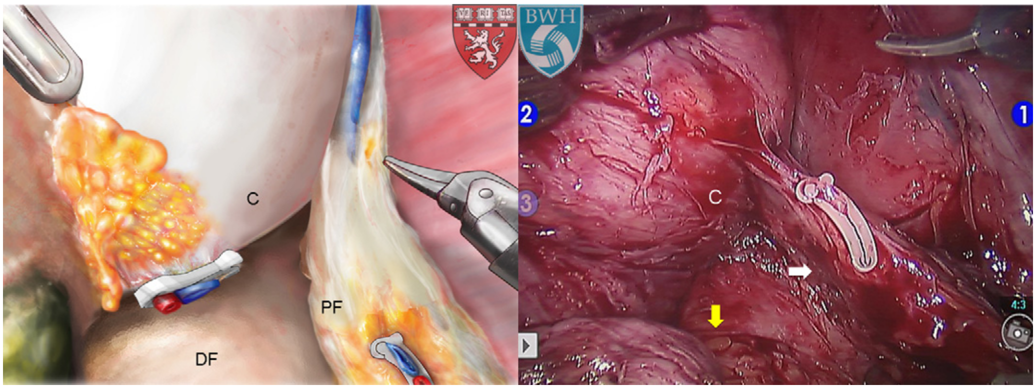


Fig. 8 – Denonvillier's fascia (DF) dissected away from the prostate capsule posteriorly, with the yellow arrow indicating the DF edge with underlying prerectal fat. After lateral pedicle division, intrafascial nerve sparing is performed by dissecting the prostate capsule away from the inner prostatic fascia (PF; white arrow), covering the medial neurovascular bundle (NVB) border. NVB veins lateral to the PF also serve as a landmark for the medial aspect of the NVB during intrafascial nerve sparing.
C = prostatic capsule; DF = Denonvillier's fascia; PF = prostatic fascia.

After achieving bilateral NVB release up to or beyond the midprostate, the DVC is divided and selectively sutured [12]. The fourth arm is used to gently rotate the prostate medially while completing antegrade apical nerve sparing [13].

2.2.5. Technique modification to avoid countertraction of the neurovascular bundle

With NS-C, assistant suction tip countertraction was applied to provide lateral tension on the NVB, and robotic Maryland dissector countertraction was applied to the left NVB distal to the lateral pedicle to facilitate right- and left-sided nerve sparing, respectively (Fig. 10). However with NS-0C, we modified our technique to avoid assistant/surgeon lateral countertraction to dissect prostate away from the NVB instead of the NVB away from the prostate. Moreover, we decreased robotic scissors excursion with blunt dissection during intrafascial nerve sparing to attenuate tension on the NVB.

2.3. Outcomes

Sexual function was assessed preoperatively and at 5 and 12 mo (within 30 d) postoperatively by the EPIC, scored from 0 to 100, with higher scores representing better outcomes [14]. Because potency outcomes are often presented in the literature, we dichotomized EPIC responses to

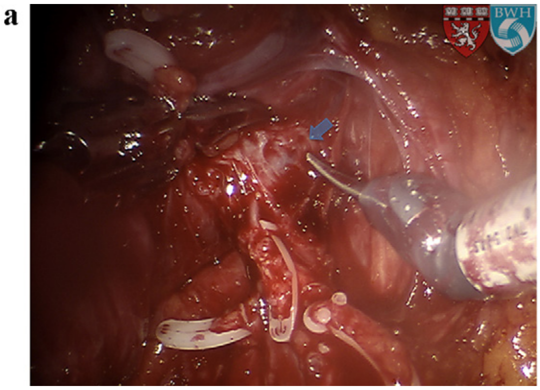


Fig. 9 – (a) Intentional venotomy (blue arrow) to initiate vein splitting for interfascial nerve sparing after lateral pedicle division, with prerectal fat rather than Denonvillier's fascia posteriorly. Veins are commonly the medial neurovascular bundle (NVB) component just outside the inner prostatic fascia. (b) Following interfascial nerve-sparing venotomy, the NVB vein is split, leaving the medial edge of the venous wall (blue arrow), inner prostatic fascia, and fibro-adipose components of the NVB with the prostate. Fibroadipose tissue is also noted on the medial border of the NVB (yellow arrow).
PF = prostatic fascia; NVB = neurovascular bundle.

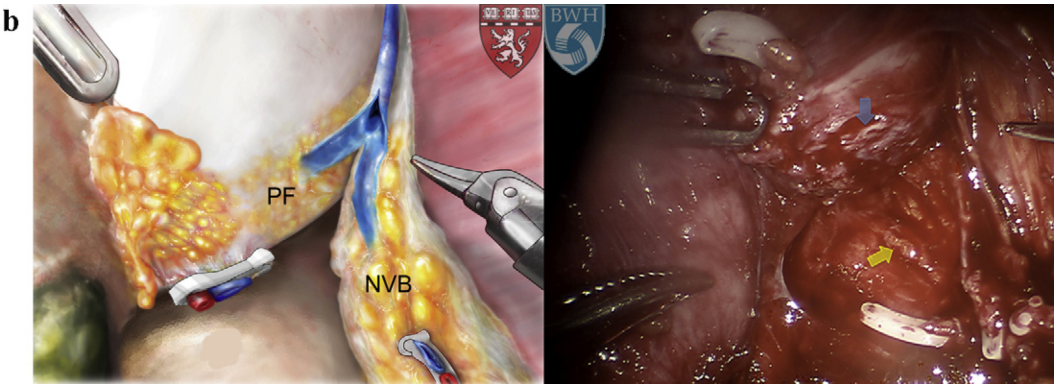


Fig. 9. (Continued).

define *potency* as erections firm enough for sexual activity or intercourse [5]. We do not routinely prescribe potency rehabilitation because of level 1 evidence to the contrary [15]. However, 21 NS-0C patients (6.1%) and 23 NS-C patients (8.6%) pursued potency rehabilitation, and sexual function was not significantly better with rehabilitation. Therefore, it was not included as a covariate in multivariable analysis.

2.4. *Statistical analysis*

SAS v.9.2 statistical software (SAS Institute, Cary, NC, USA) was used for statistical analysis. Wilcoxon rank sum, χ^2, Fisher exact, and *t* tests were used for bivariable analyses. Postoperative QoL outcomes were nonparametric; therefore, median values were assessed. Comparison of unilateral and non–nerve-sparing functional outcomes did not reveal significant variation; therefore, these categories were collapsed. Stepwise linear regression was performed to determine factors influencing the recovery of sexual function, estimated blood loss (EBL), and operative time. Similarly, stepwise logistic regression was performed to determine factors influencing positive surgical margin (PSM) and recovery of potency. Survival curves were plotted, including men surveyed beyond 5- and 12-mo assessment windows, and time to potency compared with the log-rank test.

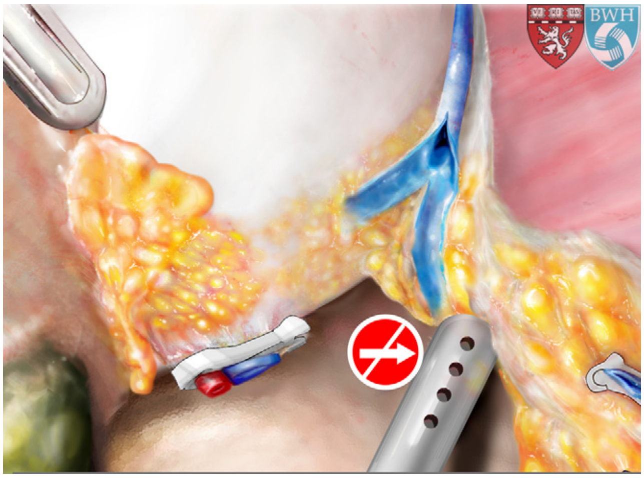


Fig. 10 – Demonstration of the prior technique of nerve sparing with assistant suction (or robotic instrument) neurovascular bundle counter-traction to facilitate nerve-sparing dissection that leads to neuropraxia.

3. Results

3.1. *Characteristics of the study population*

The response rates at 5 and 12 mo were 83.1% and 70.8%, with 10.2% and 22.7% of subjects reached by telephone, respectively. One hundred twenty-two men responded outside of the 5- and 12-mo windows. Men undergoing NS-0C versus NS-C were older ($p = 0.001$), were more likely to be nonwhite ($p = 0.005$), had worse baseline mean sexual function (71.8 vs 77.2; $p = 0.016$), had higher preoperative prostate-specific antigen (PSA) levels ($p = 0.023$), and had higher biopsy Gleason grade ($p < 0.001$; Table 1).

3.2. *Outcomes*

In unadjusted analyses, NS-0C versus NS-C was associated with shorter operative times ($p = 0.012$) and higher EBL ($p < 0.001$), although postoperative hematocrit change and transfusions were similar (Table 2). Bilateral nerve sparing was employed with greater frequency during NS-0C versus NS-C (84.2% vs 75.4%; $p = 0.006$). In addition, NS-0C versus NS-C was associated with larger tumors ($p < 0.001$) and higher pathologic Gleason grade ($p = 0.004$); however, pathologic stage and PSM were similar (Table 3).

Five-month overall sexual function scores were higher (median: 20 vs 10; $p < 0.001$) for NS-0C versus NS-C (Table 4). Although the difference was most pronounced for bilateral intrafascial nerve sparing overall (33.4 vs 15.0; $p < 0.001$) and in preoperatively potent men (35.8 vs 16.6; $p < 0.001$), NS-0C versus NS-C sexual function scores were also improved with other nerve-sparing approaches. Improved 5-mo sexual function was also evident in age-stratified comparisons of NS-0C versus NS-C (Table 5), and NS-0C was associated with higher sexual function scores at 5 mo in all ages except for men >70 yr of age, where no differences were observed. In terms of potency, only NS-0C versus NS-C bilateral intrafascial nerve sparing demonstrated earlier recovery (42.9% vs 26.2%; $p = 0.029$), particularly for preoperatively potent men (45.0% vs 28.4%; $p = 0.039$).

Table 1 – Baseline demographics and tumor characteristics by nerve-sparing technique

	Without countertraction ($n = 342$)	With countertraction ($n = 268$)	p value
Age, yr, mean ± SD	59.6 ± 6.5	57.9 ± 6.6	0.001
BMI, kg/m, mean ± SD	28.8 ± 4.8	28.5 ± 4.9	0.385
Baseline sexual function, mean ± SD	71.8 ± 29.4	77.2 ± 25.2	0.016
Potent[*], no. (%)	286 (83.9)	234 (87.3)	0.233
Race, no. (%)			
White	306 (89.5)	257 (95.9)	0.005
Black	20 (5.9)	9 (3.4)	–
Other	16 (4.7)	2 (0.8)	–
Preoperative PSA, median ng/ml (IQR)	5.0 (4.0–6.9)	4.8 (3.9–6.0)	0.023
Clinical stage, no. (%)			
T1c	323 (94.4)	262 (97.8)	0.105
T2a	10 (2.9)	5 (1.9)	–
T2b	6 (1.8)	0 (0)	–
T2c	3 (0.9)	1 (0.4)	–
Biopsy Gleason score, no. (%)			
3 + 2	0 (0)	1 (0.4)	<0.001
3 + 3	166 (48.5)	172 (64.2)	–
3 + 4	114 (33.3)	63 (23.5)	–
4 + 3	44 (12.9)	22 (8.2)	–
4 + 4	16 (4.7)	4 (1.5)	–
3 + 5	0 (0)	3 (1.1)	–
4 + 5	1 (0.3)	3 (1.1)	–
5 + 4	1 (0.3)	0 (0)	–

SD = standard deviation; BMI = body mass index; PSA = prostate-specific antigen; EPIC = Expanded Prostate Cancer Index Composite.

[*] *Potent* defined from EPIC as quality of erection firm enough for sexual activity.

Table 2 – Perioperative outcomes by nerve-sparing technique

	Without countertraction ($n = 342$)	With countertraction ($n = 268$)	p value
EBL, ml, median (IQR)	175 (150–220)	150 (100–200)	<0.001
Hematocrit change, median (IQR)[*]	8.4 (6.4–10.6)	8.0 (6.2–10.3)	0.119
Operative time, min, median (IQR)	130 (120–146)	135 (122.5–150)	0.012
Blood transfusion, no. (%)	3 (0.9)[†]	0 (0)	0.124
Nerve-sparing approach, no. (%)			
Bilateral nerve sparing	288 (84.2)	202 (75.4)	0.006
Unilateral/no nerve sparing	54 (15.8)	66 (24.6)	–

IQR = interquartile range; EBL = estimated blood loss.

[*] Difference between preoperative and recovery room hematocrit.

[†] One patient with Von Willebrand disease and one patient on clopidogrel for a prosthetic heart valve.

In adjusted analyses (Table 6), although bilateral versus unilateral/non–nerve sparing, younger age, and better baseline sexual function were associated with better 5- and 12-mo sexual function (all $p \le 0.031$), NS-0C versus NS-C was associated with better 5-mo sexual function ($p < 0.001$) but no improvement at 12 mo. Similarly, although younger age and better baseline sexual function were associated with better 5- and 12-mo potency (all $p \le 0.028$; Table 7), NS-0C versus NS-C and bilateral versus no or unilateral nerve sparing were associated with better 5-mo potency (all $p \le 0.046$). In addition, inclusion of responders outside the 5- and 12-mo windows with survival analysis revealed earlier recovery of potency for NS-0C versus NS-C ($p < 0.001$; Fig. 11).

Higher body mass index (BMI), prostate volume, and NS-0C were associated with longer operative times (all $p \le 0.009$); higher BMI, no or unilateral versus bilateral nerve sparing, and NS-0C were associated with greater EBL (all $p \le 0.008$; Table 8). Greater tumor size and stage and higher preoperative PSA levels (all $p \le 0.003$) were associated with more PSM, while greater gland volume ($p = 0.033$) was associated with fewer PSM (Table 9). NS-0C versus NS-C and subanalyses comparing bilateral and unilateral intra-, inter-, and non–nerve sparing did not demonstrate an effect of nerve-sparing techniques on PSM.

4. Discussion

Hinman's widely read urologic surgery atlas states, "The main function of an assistant is to provide exposure. This is accomplished not only by retraction... but by anticipating the next move and grasping the appropriate layer at the right time and place" [16]. Trainees are instructed in and develop this technique until it becomes second nature, and

Table 3 – Pathologic outcomes by nerve-sparing technique

	Without countertraction ($n = 342$)	With countertraction ($n = 268$)	*p* value
Gland volume, g, median (IQR)	49.8 (41.5–63)	51.5 (44–61)	0.154
Tumor size, cm, median (IQR)	1.4 (1.0–1.8)	1.2 (0.7–1.6)	<0.001
Pathologic stage, no. (%)			
T0	1 (0.3)	1 (0.4)	0.100
T2a	29 (8.5)	42 (15.7)	–
T2b	9 (2.6)	10 (3.7)	–
T2c	242 (70.8)	178 (66.4)	–
T3a	45 (13.2)	27 (10.1)	–
T3b	16 (4.7)	10 (3.7)	–
Gleason grade, no. (%)			
3 + 2	1 (0.3)	0 (0)	0.004
3 + 3	93 (27.3)	113 (42.3)	–
3 + 4	147 (43.1)	101 (37.8)	–
4 + 3	83 (24.3)	39 (14.6)	–
4 + 4	10 (2.9)	8 (3.0)	–
3 + 5	0 (0)	1 (0.4)	–
4 + 5	6 (1.8)	5 (1.9)	–
5 + 4	1 (0.3)	0 (0)	–
PSM, no. (%)	55 (16.1)	31 (11.6)	0.112

IQR = interquartile range; PSM = positive surgical margin.

attending surgeons may struggle without this valued skill during open and laparoscopic or robotic surgery. During RP, the assistant may provide NVB countertraction during nerve sparing without explicit intraoperative instruction to avoid doing so. For instance, over the 30-mo study period, there were 16 different assistant trainee surgeons; review of intraoperative video and prospective data revealed that all trainees initiated NVB suction tip countertraction until explicit instruction not to do so with NS-0C. Moreover, the attending surgeon was unaware of the neuropraxia sequelae of assistant and robotic instrument NVB countertraction until observation of skillful RRP and subsequent technical modification, illustrating the importance of surgical technique over surgical approach (RRP vs RARP) [17].

Many anatomic studies emphasize attaining the proper nerve-sparing plane, and RARP magnification and decreased venous oozing secondary to carbon dioxide insufflation facilitate visualization for intrafascial versus interfascial nerve sparing. Although experience is required for recognition of tissue characteristics and anatomic planes, few studies emphasize the importance of minimizing NVB traction during RRP or RARP and provide sparse technical details for others to replicate nerve-sparing techniques and outcomes. Mulhall et al. identified NVB countertraction as a source of postprostatectomy neurogenic erectile dysfunction (ED) [18]. Kaul et al. asserted that endopelvic fascia sparing and delayed DVC ligation reduced NVB traction without mention of assistant or surgeon-specific technique as it relates to NVB tension [19]. Although Rassweiler acknowledged that improved intrafascial nerve-sparing outcomes may be secondary to minimizing traction injury [20], avoidance of NVB traction was mentioned only during SV dissection [21]. Zorn et al. mentioned use of gentle NVB traction while achieving the correct nerve-sparing plane [22]. For low-risk disease features, Mattei et al. described a lateral approach prior to bladder neck division for tension-free, athermal nerve sparing to attenuate NVB tension neuropraxia [23]; however, there was no comparison with prior technique. Tewari et al. minimize traction injury by using sharp dissection and avoiding excessive pull on the NVB without mention of countertraction or technique-specific outcomes [24]. However, media from both studies demonstrate assistant/surgeon NVB countertraction, which

Table 4 – Recovery of function outcomes by nerve-sparing approach

	Postoperative time					
	5 mo			12 mo		
	Without countertraction	With countertraction	*p* value	Without countertraction	With countertraction	*p* value
Sexual function, median (IQR)	20 (5–38.4)	10 (0–23.4)	<0.001	21.6 (5.0–48.4)	25 (10.0–51.6)	0.354
Preoperatively potent men, no. (IQR)	25 (6.6–43.4)	10 (0–25.0)	<0.001	31.6 (6.6–53.4)	26.6 (11.6–53.4)	0.861
Preoperatively potent, bilateral intrafascial nerve sparing, no. (IQR)	35.8 (15.8–64.2)	16.6 (5–38.4)	<0.001	35.9 (21.6–74.2)	46.7 (16.6–64.2)	0.762
Bilateral intrafascial nerve sparing, no. (IQR)	33.4 (10–63.4)	15 (5.0–33.4)	<0.001	32.5 (21.6–73.4)	44.2 (15.0–63.4)	0.957
Combined interfascial and intrafascial nerve sparing, no. (IQR)	21.6 (10–46.6)	10 (026.6)	0.003	24.1 (5–46.6)	26.6 (16.6–36.6)	0.675
Bilateral interfascial nerve sparing, no. (IQR)	17.5 (0–31.6)	0 (0–10.0)	0.004	24.1 (6.6–53.4)	11.6 (0.0–25.0)	0.105
Potency, no. (%)	55 (24.9)	36 (18.4)	0.108	35 (34.7)	58 (33.5)	0.849
Preoperatively potent men, no. (%)	53 (28.5)	34 (19.8)	0.054	35 (42.2)	52 (34.4)	0.242
Preoperatively potent, bilateral intrafascial nerve sparing, no. (%)	27 (45.0)	27 (28.4)	0.039	10 (50.0)	39 (54.2)	0.803
Bilateral intrafascial nerve sparing, no. (%)	27 (42.9)	27 (26.2)	0.029	10 (45.5)	41 (52.6)	0.556
Combined interfascial and intrafascial nerve sparing, no. (%)	17 (28.8)	7 (18.9)	0.276	9 (34.6)	8 (22.2)	0.280
Bilateral interfascial nerve sparing, no. (%)	9 (14.5)	0 (0.0)	0.129	11 (36.7)	2 (13.3)	0.104

IQR = interquartile range.

Table 5 – Age-stratified recovery of sexual function and potency by nerve-sparing technique

	5 mo			12 mo		
	Without countertraction (*n* = 221)	With countertraction (*n* = 197)	*p* value	Without countertraction (*n* = 102)	With countertraction (*n* = 173)	*p* value
Sexual function, median (IQR)						
Age:						
40–49	28.4 (25–80)	21.6 (5–38.4)	0.037	42.5 (28.3–53.4)	53.4 (26.6–63.4)	0.472
50–59	23.4 (5–48.4)	15 (5–27.5)	0.036	38.4 (16.6–60)	35.8 (15–53.4)	0.192
60–69	15 (0–35)	0 (0–10)	<0.001	10 (0–31.6)	16.6 (5–31.6)	<0.001
≥70	12.5 (5–15)	5 (0–12.5)	0.403	2.5 (0–5)	5 (0–12.5)	0.244
Potency, no. (%)						
Age:						
40–49	7 (46.7)	5 (27.8)	0.314	4 (50.0)	11 (52.4)	0.909
50–59	31 (33.3)	22 (22.9)	0.111	21 (56.8)	33 (44.6)	0.227
60–69	16 (15.0)	9 (11.4)	0.482	10 (19.2)	14 (18.9)	0.965
≥70	1 (16.7)	0 (0)	0.389	0 (0)	0 (0)	–
Preoperatively potent, no. (%)						
Age						
40–49	7 (46.7)	5 (29.4)	0.314	4 (50.0)	11 (52.4)	0.909
50–59	30 (34.5)	22 (25.3)	0.185	21 (56.8)	30 (45.5)	0.271
60–69	15 (18.5)	7 (10.6)	0.181	10 (27.8)	11 (18.0)	0.260
≥70	1 (33.3)	0 (0)	0.361	0 (0)	0 (0)	–

IQR = interquartile range.

Table 6 – Linear regression model for postoperative sexual function

	5 mo			12 mo		
Covariate	PE	SE	*p* value	PE	SE	*p* value
Gland volume	−0.05	0.06	0.347	−0.10	0.08	0.214
Age	−0.63	0.18	<0.001	−0.94	0.24	<0.001
BMI	−0.35	0.23	0.130	−0.50	0.29	0.085
Baseline sexual function	0.18	0.04	<0.001	0.17	0.06	0.005
Bilateral vs No/unilateral nerve sparing	9.69	2.77	<0.001	7.70	3.55	0.031
Nerve sparing without vs with countertraction	10.90	2.16	<0.001	1.76	3.08	0.568

PE = parameter estimate; SE = standard error; BMI = body mass index.

Table 7 – Logistic regression model for postoperative potency

	5 mo			12 mo		
Covariate	OR	95% CI	*p* value	OR	95% CI	*p* value
Gland volume	0.99	0.98–1.01	0.421	0.99	0.98–1.01	0.432
Age	0.95	0.92–0.99	0.028	0.94	0.89–0.98	0.004
BMI	0.96	0.90–1.01	0.108	0.95	0.90–1.01	0.120
Baseline sexual function	1.03	1.01–1.04	<0.001	1.02	1.00–1.03	0.019
Bilateral vs no/unilateral nerve sparing	6.48	1.94–21.6	0.002	2.07	0.98–4.41	0.058
Nerve sparing without vs with countertraction	1.69	1.01–2.83	0.046	1.47	0.82–2.64	0.197

OR = odds ratio; CI = confidence interval; BMI = body mass index.

Table 8 – Linear regression model for operative time and estimated blood loss

	Operative time			EBL		
Covariate	PE	SE	*p* value	PE	SE	*p* value
BMI	0.75	0.19	<0.001	3.56	0.65	<0.001
Bilateral vs no/unilateral nerve sparing	0.66	2.39	0.783	−23.67	8.16	0.004
LND vs not performed	−3.88	2.81	0.168	4.16	9.58	0.665
Prostate volume	0.12	0.05	0.013	0.23	0.17	0.166
Nerve sparing without vs with countertraction	−6.65	1.90	0.001	20.88	6.49	0.001

EBL = estimated blood loss; PE = parameter estimate; SE = standard error (SE); BMI = body mass index; LND = lymph node dissection.

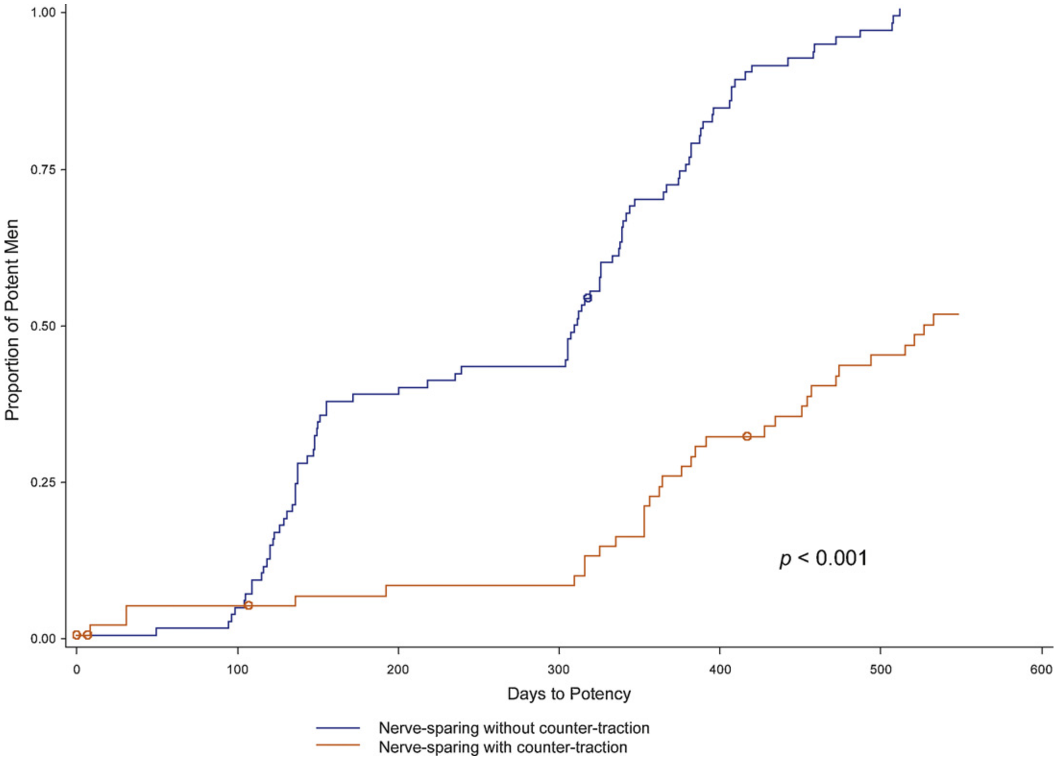


Fig. 11 – Time to potency for nerve sparing with (red) versus without countertraction (blue).

Table 9 – Logistic regression model for positive surgical margins

Covariate	OR	95% CI	*p* value
BMI	1.01	0.95–1.08	0.678
Gland volume	0.98	0.96–1.00	0.017
Tumor size, cm	1.88	1.17–3.04	0.010
Bilateral vs no/unilateral nerve sparing	0.64	0.32–1.27	0.201
Total Gleason 7 vs Gleason ≤6	0.69	0.33–1.45	0.330
Total Gleason 8 vs Gleason ≤6	0.83	0.22–3.19	0.790
Total Gleason 9 vs Gleason ≤6	0.35	0.07–1.88	0.223
pT2 vs pT3b	0.16	0.05–0.46	<0.001
pT3a vs pT3b	1.16	0.38–3.50	0.796
Preoperative PSA	1.14	1.05–1.24	0.002
Nerve sparing without vs with countertraction	1.07	0.60–1.91	0.831

OR = odds ratio; CI = confidence interval; BMI = body mass index; PSA = prostate-specific antigen.

also pervades live demonstrations and videos by high-volume RRP and RARP surgeons.

Our study has several important findings. First, despite older age and lower baseline sexual function, men undergoing NS-0C experienced significantly improved 5-mo sexual function and potency outcomes compared to NS-C. In adjusted analysis, NS-0C EPIC sexual function scores were 10.9 points higher than NS-C, falling within the 10- to 12-point range of minimally important differences in EPIC sexual function score [25]. Therefore, earlier recovery of sexual function was both statistically and clinically significant. This improvement was most pronounced for bilateral intrafascial versus interfascial or combination nerve sparing. In addition, analyses of subjects responding outside of the 5- and 12-mo time windows also demonstrated earlier recovery of potency with NS-0C, and improvement is likely secondary to attenuating stretch neuropathy. Stretch neuropathy has been described in orthopedic, cardiothoracic, and otolaryngology literature [26–28]. Wall et al. found that 6% nerve stretch temporarily decreases action potentials by 70%, while 12% stretch for more than an hour results in unrecoverable complete blockage of conduction [28]. Furthermore, avoidance of traction on the accessory nerve during head and neck dissections prevents postoperative shoulder disability [29,30]. To our knowledge, this is the first study to quantify the sexual function benefits of minimizing NVB tension and illustrate a stepwise technique for doing so.

Second, although NS-0C was associated with higher EBL, it does not prolong operative times or increase PSM. However, the adjusted EBL difference of 21 ml was not clinically significant, and no significant transfusion differences were observed. Shortened operative times with NS-0C suggest that although NS-C may facilitate dissection of the nerve-sparing plane, increased surgeon experience overcomes initial NS-0C inefficiency. Finally, bilateral nerve sparing was employed more often with NS-0C versus NS-C, despite more aggressive biopsy features without significantly more PSM.

Our study must be considered within the context of the study design. First, although data were prospectively collected, this is a single-surgeon retrospective study subject to biases inherent to this study design versus a randomized controlled trial (RCT). However, surgical RCTs are difficult to implement, as surgeons become biased to certain techniques with more experience. Moreover, multisurgeon RCTs are limited because of heterogeneity in surgical technique [4]. However, we used third-party collection of self-reported QoL outcomes with validated instruments, and our goal is to illustrate NS-0C technique and benefits to help others improve outcomes and shorten learning curves, as the use of NS-C may be widespread. Second, learning curve effects were not quantifiable because of the absence of overlap between NS-C and NS-0C techniques. However, we excluded RARP procedures performed prior to the study period of consecutive RARP to avoid potential confounding resulting from inconsistent dissection of nerve-sparing planes and learning curve effects. Third, all RARP procedures were performed by a single fellowship–trained surgeon, and prostatectomy outcomes are inherently technique specific. For instance, others may assert that the bipolar energy with our cut-and-peel technique may be negated with clips; however, we maintain that bipolar is used commonly during neurosurgery, and high division may have fewer sequelae compared to the vessel distance needed to clip and divide SV arterioles. In addition, a disadvantage of clipping thin structures includes potential clip dislodgement into the bladder, which may present as bladder stones. However, the presentation of video demonstration allows reproducibility rather than the use of nonspecific terms that may vary in meaning and application for other surgeons. Fourth, our anatomic observation that veins consistently serve as the medial NVB border/component and landmarked for intrafascial nerve sparing or intentionally split for interfascial nerve sparing must be corroborated by others. Fifth, we incurred loss to follow-up despite repeated attempts to contact nonresponders, and we may be underpowered to detect NS-0C benefits at 12 mo. This is inevitable with travel to referral centers, but responders and nonresponders did not differ in baseline characteristics. Sixth, although we eliminated active assistant and surgeon lateral tension on the NVB (with the nondissecting robotic Maryland) and decreased blunt dissection excursion during nerve sparing with NS-0C, blunt dissection itself transmits tension on the NVB. However, it is extremely challenging to perform intrafascial nerve sparing without employing any blunt dissection. Finally, additional follow-up is needed to assess long-term sexual function as recovery plateaus at or beyond 18–24 mo postprostatectomy [31].

5. Conclusions

Although nerve-sparing RP improves sexual function, there may be overreliance on the use of countertraction to dissect the NVB away from the prostate, and underemphasis on avoidance of NVB countertraction. However, subtle technical modification to avoid countertraction when dissecting prostate from the NVB rather than NVB from prostate attenuates neuropraxia and improves early sexual function/potency recovery. Counterintuitively, surgeons must instruct assistants not to help during nerve sparing. Longer follow-up is needed to determine the effect of reduced NVB tension on long-term sexual function outcomes and its potential benefits for men with varying degrees of baseline ED.

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, Kowalczyk.
Acquisition of data: Kowalczyk, Huang, Hevelone, Yu, Ulmer, Kaplan, Patel.
Analysis and interpretation of data: Kowalczyk, Yu, Hu.
Drafting of the manuscript: Kowalczyk, Hu.
Critical revision of the manuscript for important intellectual content: Kowalczyk, Yu, Hu.
Statistical analysis: Hevelone, Lipsitz.
Obtaining funding: None.
Administrative, technical, or material support: Hu, Lipsitz.
Supervision: Hu.
Other (specify): None.

Financial disclosures: I certify that all conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript (eg, employment/affiliation, grants or funding, consultancies, honoraria, stock ownership or options, expert testimony, royalties, or patents filed, received, or pending), are the following: Dr Kowalczyk receives salary support from the Robert and Kathy Salipante Minimally Invasive Urologic Oncology Fellowship; Dr Huang receives salary support from a Taipei City Hospital Research Fellowship; Dr Ulmer receives salary support from the New York Academy of Medicine David E. Rogers Fellowship and the American Urologic Association Foundation Herbert Brendler Summer Medical Student Fellowship Awarded; Dr Yu receives salary support from an American Urological Association Foundation Research Fellowship Award; and Dr Hu receives salary support from US Department of Defense Physician Training Award W81XWH-08-1-0283.

Funding/Support and role of the sponsor: None.

Acknowledgment statement: The authors are grateful to Dr Patrick C. Walsh for his invitation to observe surgery, which inspired this technique and study.

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.2011.05.001 and via www.europeanurology.com.

References

[1] Walsh PC. Anatomic radical prostatectomy: evolution of the surgical technique. J Urol 1998;160:2418–24.
[2] Hu J, Gu X, Lipsitz S, et al. Comparative effectiveness of minimally invasive vs open radical prostatectomy. JAMA 2009;302:1557–64.
[3] Schroeck FR, Krupski TL, Sun L, et al. Satisfaction and regret after open retropubic or robot-assisted laparoscopic radical prostatectomy. Eur Urol 2008;54:785–93.
[4] Hu JC, Yu H-y, Kowalczyk KJ. Challenges of interpreting and improving radical prostatectomy outcomes: technique, technology, training, and tactical reporting. Eur Urol 2011;59:1073–4.
[5] Vickers A, Savage C, Bianco F, et al. Cancer control and functional outcomes after radical prostatectomy as markers of surgical

quality: analysis of heterogeneity between surgeons at a single cancer center. Eur Urol 2011;59:317–22.

[6] Walsh PC, Marschke P, Ricker D, Burnett AL. Use of intraoperative video documentation to improve sexual function after radical retropubic prostatectomy. Urology 2000;55:62–7.

[7] Touijer K, Kuroiwa K, Saranchuk JW, et al. Quality improvement in laparoscopic radical prostatectomy for pt2 prostate cancer: impact of video documentation review on positive surgical margin. J Urol 2005;173:765–8.

[8] Freire M, Choi W, Lei Y, Carvas F, Hu JC. Overcoming the learning curve for robotic-assisted laparoscopic radical prostatectomy. Urol Clin North Am 2010;37:37–47.

[9] Freire MP, Weinberg AC, Lei Y, et al. Anatomic bladder neck preservation during robotic-assisted laparoscopic radical prostatectomy: description of technique and outcomes. Eur Urol 2009;56:972–80.

[10] Berry A, Korkes F, Hu J. Landmarks for consistent nerve sparing during robotic-assisted laparoscopic radical prostatectomy. J Endourol 2008;22:1565–8.

[11] Williams SB, Alemozaffar M, Lei Y, et al. Randomized controlled trial of barbed polyglyconate versus polyglactin suture for robot-assisted laparoscopic prostatectomy anastomosis: technique and outcomes. Eur Urol 2010;58:875–81.

[12] Lei Y, Alemozaffar M, Williams SB, et al. Athermal division and selective suture ligation of the dorsal vein complex during robot-assisted laparoscopic radical prostatectomy: description of technique and outcomes. Eur Urol 2011;59:235–43.

[13] Huang AC, Kowalczyk KJ, Hevelone ND, et al. The impact of prostate size, median lobe, and prior benign prostatic hyperplasia intervention on robot-assisted laparoscopic prostatectomy: technique and outcomes. Eur Urol 2011;59:595–603.

[14] Wei J, Dunn R, Litwin M, Sandler HM, Sanda MG. Development and validation of the Expanded Prostate Cancer Index Composite (EPIC) for comprehensive assessment of health-related quality of life in men with prostate cancer. Urology 2000;56:899–905.

[15] Montorsi F, Brock G, Lee J, et al. Effect of nightly versus on-demand vardenafil on recovery of erectile function in men following bilateral nerve-sparing radical prostatectomy. Eur Urol 2008;54: 924–31.

[16] Hinman F, Stempen PH. Atlas of urologic surgery. Philadelphia, PA: W.B. Saunders; 1989.

[17] Hu JC. Why I perform robotic-assisted laparoscopic radical prostatectomy, despite more incontinence and erectile dysfunction diagnoses compared to open surgery: it's not about the robot. Eur Urol 2010;57:544–5.

[18] Mulhall JP, Slovick R, Hotaling J, et al. Erectile dysfunction after radical prostatectomy: hemodynamic profiles and their correlation with the recovery of erectile function. J Urol 2002;167:1371–5.

[19] Kaul S, Savera A, Badani K, Fumo M, Bhandari A, Menon M. Functional outcomes and oncological efficacy of Vattikuti Institute prostatectomy with veil of Aphrodite nerve sparing: an analysis of 154 consecutive patients. BJU Int 2006;97:467–72.

[20] Rassweiler J. Intrafascial nerve-sparing laparoscopic radical prostatectomy: do we really preserve relevant nerve-fibres. Eur Urol 2006;49:955–7.

[21] Rassweiler J, Wagner AA, Moazin M, et al. Anatomic nerve-sparing laparoscopic radical prostatectomy: comparison of retrograde and antegrade techniques. Urology 2006;68:587–91.

[22] Zorn KC, Gofrit ON, Orvieto MA, Mikhail AA, Zagaja GP, Shalhav AL. Robotic-assisted laparoscopic prostatectomy: functional and pathologic outcomes with interfascial nerve preservation. Eur Urol 2007;51:755–63.

[23] Mattei A, Naspro R, Annino F, Burke D, Guida Jr R, Gaston R. Tension and energy-free robotic-assisted laparoscopic radical prostatectomy with interfascial dissection of the neurovascular bundles. Eur Urol 2007;52:687–95.

[24] Tewari A, Takenaka A, Mtui E, et al. The proximal neurovascular plate and the tri zonal neural architecture around the prostate gland: importance in the athermal robotic technique of nerve sparing prostatectomy. BJU Int 2006;98:314–23.

[25] Dunn RL, Sanda MG, Wei JT. Minimally important difference for the expanded prostate cancer index composite. Abstract presented at ISQOL; October 28, 2009; New Orleans, LA, USA.

[26] Kirsh M, Magee K, Gago O, Kahn DR, Sloan H. Brachial plexus injury following median sternotomy incision. Ann Thorac Surg 1971;11:315–9.

[27] Sharma A, Parmley C, Sreeram G, Grocott HP. Peripheral nerve injuries during cardiac surgery: risk factors, diagnosis, prognosis, and prevention. Anesth Analg 2000;91:1358–69.

[28] Wall E, Massie J, Kwan M, Rydevik BL, Myers RR, Garfin SR. Experimental stretch neuropathy. Changes in nerve conduction under tension. J Bone Joint Surg Br 1992;74:126–9.

[29] Remmler D, Byers R, Scheetz J, et al. A prospective study of shoulder disability resulting from radical and modified neck dissections. Head Neck Surg 1986;8:503–9.

[30] Erisen L, Basel B, Irdesel J, et al. Shoulder function after accessory nerve–sparing neck dissections. Head Neck 2004;26:967–71.

[31] Litwin MS, Melmed GY, Nakazon T. Life after radical prostatectomy: a longitudinal study. J Urol 2001;166:587–92.

EUROPEAN UROLOGY 61 (2012) 1222–1228

available at www.sciencedirect.com
journal homepage: www.europeanurology.com

European Association of Urology

Surgery in Motion

Technical Refinement and Learning Curve for Attenuating Neurapraxia During Robotic-Assisted Radical Prostatectomy to Improve Sexual Function

Mehdrad Alemozaffar[a], *Antoine Duclos*[b], *Nathanael D. Hevelone*[b], *Stuart R. Lipsitz*[b], *Tudor Borza*[a], *Hua-Yin Yu*[a], *Keith J. Kowalczyk*[c], *Jim C. Hu*[d,*]

[a] *Division of Urologic Surgery, Brigham and Women's, Harvard Medical School, Boston, MA, USA;* [b] *Center for Surgery and Public Health, Brigham and Women's, Harvard Medical School, Boston, MA, USA;* [c] *Department of Urology, Georgetown Medical Center, Washington, DC, USA;* [d] *Institute of Urologic Oncology, Department of Urology, David Geffen School of Medicine at UCLA, Los Angeles, CA, USA*

Article info

Article history:
Accepted February 29, 2012
Published online ahead of print on March 8, 2012

Keywords:
Learning curve
Sexual function
Robotic
Radical prostatectomy
Nerve-sparing
Neurapraxia

Please visit www.europeanurology.com and www.urosource.com to view the accompanying video.

Abstract

Background: While radical prostatectomy surgeon learning curves have characterized less blood loss, shorter operative times, and fewer positive margins, there is a dearth of studies characterizing learning curves for improving sexual function. Additionally, while learning curve studies often define volume thresholds for improvement, few of these studies demonstrate specific technical modifications that allow reproducibility of improved outcomes.

Objective: Demonstrate and quantify the learning curve for improving sexual function outcomes based on technical refinements that reduce neurovascular bundle displacement during nerve-sparing robot-assisted radical prostatectomy (RARP).

Design, setting, and participants: We performed a retrospective study of 400 consecutive RARPs, categorized into groups of 50, performed after elimination of continuous surgeon/assistant neurovascular bundle countertraction.

Surgical procedure: Our approach to RARP has been described previously. A single-console robotic system was used for all cases.

Outcome measurements and statistical analysis: Expanded Prostate Cancer Index Composite sexual function was measured within 1 yr of RARP. Linear regression was performed to determine factors influencing the recovery of sexual function.

Results and limitations: Greater surgeon experience was associated with better 5-mo sexual function ($p = 0.007$) and a trend for better 12-mo sexual function ($p = 0.061$), with improvement plateauing after 250–300 cases. Additionally, younger patient age (both $p < 0.02$) and better preoperative sexual function (<0.001) were associated with better 5- and 12-mo sexual function. Moreover, trainee robotic console time during nerve sparing was associated with worse 12-mo sexual function ($p = 0.021$), while unilateral nerve sparing/non–nerve sparing was associated with worse 5-mo sexual function ($p = 0.009$). Limitations include the retrospective single-surgeon design.

Conclusions: With greater surgeon experience, attenuating lateral displacement of the neurovascular bundle and resultant neurapraxia improve postoperative sexual function. However, to maximize outcomes, appropriate patient selection must be exercised when allowing trainee nerve-sparing involvement.

---

[*] Corresponding author. Institute of Urologic Oncology, Department of Urology, The David Geffen School of Medicine at UCLA, Los Angeles, CA, USA.
E-mail address: jimhumd@gmail.com (J.C. Hu).

0302-2838/$ – see back matter © 2012 European Association of Urology. Published by Elsevier B.V. All rights reserved. doi:10.1016/j.eururo.2012.02.053

1. Introduction

Opponents of prostate-specific antigen screening and aggressive treatment of low-risk prostate cancer contend that treatment-related sequelae and the costly treatment of the side-effects may be worse than a potentially indolent disease process [1,2]. For instance, the likelihood of postprostatectomy erectile dysfunction ranges from 7% to 80% [3,4], contributing to treatment regret [5,6]. This marked variation in postprostatectomy sexual function may be attributable to differences in patient selection, varying definitions of *potency*, biases stemming from varying methods of data collection (physician- vs patient-reported outcomes with or without validated quality-of-life instruments), and, most important, heterogeneous surgical techniques [3,7,8].

Surgical techniques to preserve erectile function have continued to evolve since Walsh's initial description of nerve-sparing prostatectomy approximately 30 yr ago [9]. With improved knowledge of pelvic anatomy and the advent of greater magnification during open radical prostatectomy or robot-assisted radical prostatectomy (RARP), there has been greater emphasis on full nerve sparing compared with partial nerve sparing, or on achieving the intrafascial dissection plane compared with the interfascial dissection plane during nerve sparing [10–12]. This emphasis is epitomized by histologic studies correlating recovery of sexual function with the amount of residual neurovascular bundle tissue resected with the prostate [13,14]; however, there is less emphasis on minimizing stretch neuropathy and neurapraxia that adversely affects recovery of sexual function. We recently described earlier recovery of sexual function through the elimination of active assistant and/or surgeon neurovascular bundle countertraction during RARP [15]. However, additional subtle technical refinements improve sexual function, and this paper describes and demonstrates maneuvers to further attenuate neurapraxia during nerve-sparing RARP and improve sexual function outcomes.

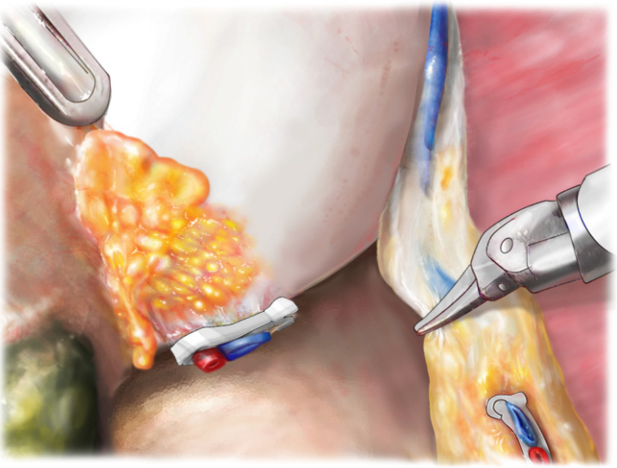


Fig. 1 – Prior technique of intermittent blunt dissection associated with transient cross-tension and lateral displacement of the neurovascular bundle as it is peeled away from the prostate during right nerve-sparing dissection.

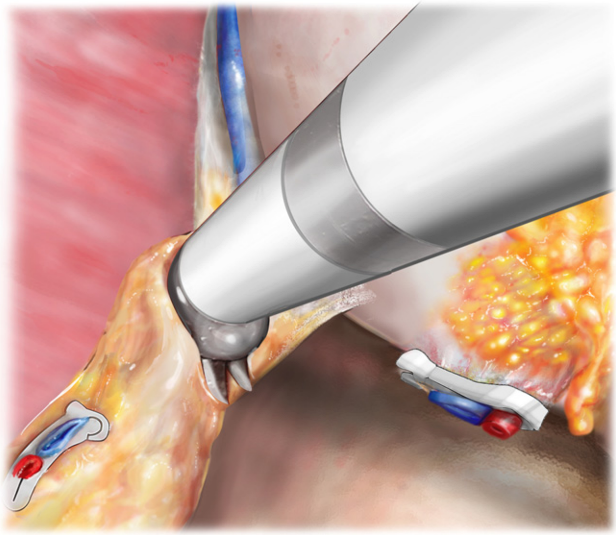


Fig. 2 – Prior technique of peeling with intermittent blunt dissection associated with transient stretch of the left neurovascular bundle.

2. Methods

2.1. Technical modification

Our approach to RARP has been described previously. A single-console robotic system was used for all cases. After eliminating continuous lateral displacement of the neurovascular bundles by the assistant and robotic surgeon to facilitate nerve-sparing dissection with countertraction [15], we focused on reducing the lateral neurovascular bundle displacement that occurs with intermittent blunt dissection resulting from a peeling motion (Figs. 1 and 2). This reduction was accomplished bilaterally with greater reliance on spreading the robotic scissors longitudinally medial to the neurovascular bundle, followed by sharp dissection (Fig. 3). In addition, during left apical nerve-sparing dissection, the robotic Maryland dissector is spread open just enough to allow sharp dissection of the medial border of the neurovascular bundle away from the left apex (Fig. 4).

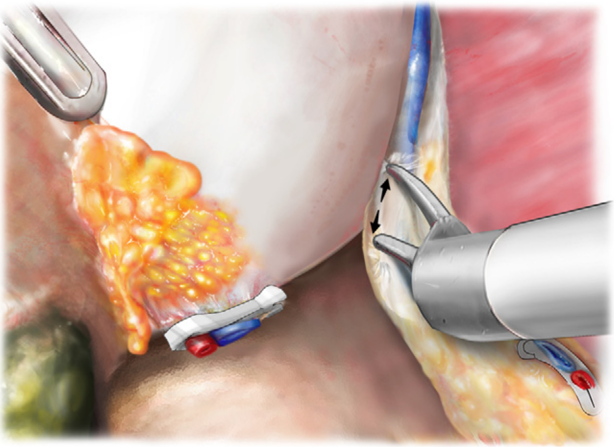


Fig. 3 – Modified right nerve-sparing dissection with spreading of scissors longitudinally along the medial edge of the neurovascular bundle to set up sharp dissection.

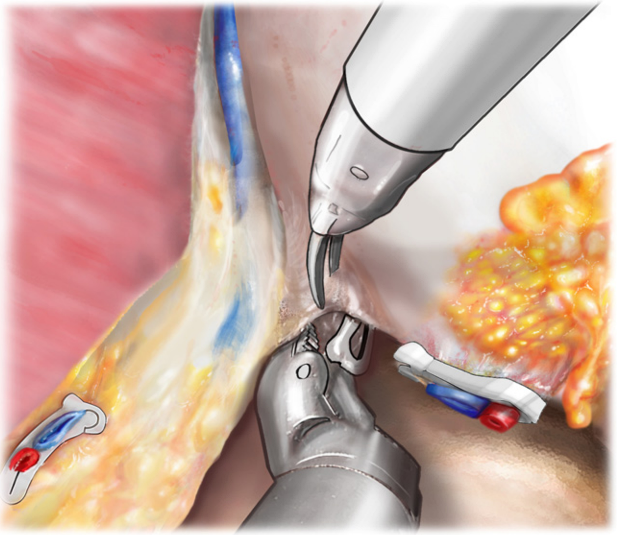


Fig. 4 – Modified left apical nerve-sparing dissection with minimal spreading of the Maryland dissector to facilitate sharp dissection and minimize lateral displacement of the left neurovascular bundle.

2.2. *Data collection*

All RARPs were performed by the senior author (J.C.H.); prior training comprised logging 76 open radical prostatectomies during residency training and 11 mo of focusing on RARP without performing nerve sparing during fellowship. After training, the first 127 cases were performed with harmonic scalpel ligation of the lateral prostatic pedicles, followed by transition to 10-mm Hem-o-Lok clip (Teleex Medical, Durham, NC, USA) ligation and another 554 cases to achieve a consistent nerve-sparing plane and eliminate active continuous lateral tension on the neurovascular bundle during nerve sparing, as determined by video review. Subsequently, 400 consecutive men underwent RARP from August 2009 to March 2011 with evolution of the aforementioned technique [15]. Residents and fellows were allowed robotic console time in the following progression, advancing after demonstration of stepwise proficiency: (1) entry into the retropubic space, (2) anterior anastomosis, (3) seminal vesicle dissection, (4) defining the posterior and anterior prostate contours, (5) selective suture ligation of dorsal venotomies, (6) posterior anastomosis, (7) apical dissection, (8) bladder-neck sparing, (9) lateral pedicle ligation, and (10) antegrade nerve sparing.

Data were prospectively collected and entered by research personnel uninvolved with clinical care into an institutional review board–approved Microsoft Access database. Thirty-nine men with seminal vesicle or extraprostatic extension (9.8%) received adjuvant radiation and/or hormonal therapy and were excluded from analysis of sexual function recovery. The Expanded Prostate Cancer Index Composite (EPIC) was administered at 5- and 12-mo postoperative follow-up appointments and by telephone, with response rates of 92% and 89%, respectively, within 30 d of these assessment points. The EPIC is scored from 0 to 100, with higher scores representing better outcomes [16]. To enhance clinical interpretability and present potency outcomes in addition to a continuous sexual function measures, we dichotomized responses to the EPIC item concerning erection quality to define *potency* as erections firm enough for sexual activity or intercourse. There were no differences in baseline responder and nonresponder demographics, tumor characteristics, or baseline sexual function scores [15].

2.3. *Statistical analysis*

Subjects were categorized by groups of 50 to assess change in mean sexual function scores with greater surgeon experience. In bivariable analyses, linear regression was used to assess trends in continuous variables over sequential groups of 50 subjects; the Cochran-Armitage trend test was used to assess trends in categorical variables over sequential groups of 50 subjects. In multivariable analyses, linear regression analyses was performed a priori with covariates that may affect sexual function, such as patient age, baseline sexual function, extent of nerve sparing (bilateral, unilateral, none), and trainee surgeon

Table 1 – Characteristics of the study population by sequential groups of 50 subjects

	1–50	51–100	101–150	151–200	201–250	251–300	301–350	351–400	*p* value
Preoperative continuous variables, mean ± standard deviation									
Age	59.2 ± 6.8	60.1 ± 7.2	61.0 ± 5.6	58.8 ± 6.5	59.1 ± 6.2	59.4 ± 6.9	59.2 ± 6.2	59.8 ± 6.9	0.702
Baseline sexual function	62.4 ± 31.0	64.1 ± 33.6	76.0 ± 22.0	74.7 ± 29.1	74.7 ± 30.1	75.2 ± 25.7	75.2 ± 31.4	76.8 ± 23.8	0.004
Body mass index, kg/m^2	30.5 ± 5.5	30.2 ± 5.4	28.3 ± 4.6	28.0 ± 4.3	27.6 ± 3.8	29.3 ± 4.4	28.5 ± 4.8	27.7 ± 5.8	0.007
PSA, ng/ml	4.7 ± 2.3	6.3 ± 5.9	6.7 ± 4.2	5.7 ± 2.9	5.3 ± 1.9	5.5 ± 2.2	6.8 ± 4.5	5.8 ± 3.6	0.675
Intraoperative/pathologic characteristics, *n* (%)									
Trainee robotic console nerve-sparing participation	0 (0.0)	6 (12.0)	5 (10.0)	7 (14.0)	1 (2.0)	9 (18.0)	11 (22.0)	27 (54.0)	<0.001
Nerve sparing									
None	2 (4.0)	5 (10.0)	3 (6.0)	2 (4.0)	7 (14.0)	2 (4.0)	2 (4.0)	1 (2.1)	0.121
Unilateral	9 (18.0)	5 (10.0)	4 (8.0)	3 (6.0)	2 (4.0)	2 (4.0)	7 (14.0)	3 (6.3)	
Bilateral	39 (78.0)	40 (80.0)	43 (86.0)	45 (90.0)	41 (82.0)	46 (92.0)	41 (82.0)	44 (91.7)	
Positive surgical margin	5 (10.0)	9 (18.0)	7 (14.0)	5 (10.0)	8 (16.0)	9 (18.0)	8 (16.0)	8 (16.0)	0.539
Gleason score									
≤6	13 (26.0)	18 (36.0)	16 (32.0)	12 (24.0)	11 (22.0)	13 (26.0)	12 (24.0)	17 (35.4)	0.814
7	37 (74.0)	28 (56.0)	32 (64.0)	36 (72.0)	36 (72.0)	34 (68.0)	34 (68.0)	28 (58.3)	
8–10	0 (0.0)	4 (8.0)	2 (4.0)	2 (4.0)	3 (6.0)	3 (6.0)	4 (8.0)	3 (6.3)	
Stage									
T2	42 (84.0)	42 (84.0)	44 (88.0)	41 (83.7)	36 (72.0)	39 (78.0)	43 (86.0)	43 (86.0)	0.754
T3a	6 (12.0)	7 (14.0)	4 (8.0)	5 (10.2)	11 (22.0)	7 (14.0)	6 (12.0)	4 (8.0)	
T3b	2 (4.0)	1 (2.0)	2 (4.0)	3 (6.1)	3 (6.0)	4 (8.0)	1 (2.0)	3 (6.0)	

PSA = prostate-specific antigen.

participation at the robotic console during nerve sparing and surgeon experience. Unilateral nerve sparing and non–nerve sparing were categorically collapsed because of the relative infrequency of these approaches. Because the sexual function curve may not be a linear function of surgeon experience, we also considered models with quadratic or logarithmic terms in surgeon experience and chose the model with the best fit [17]. The adjusted sexual function outcomes were plotted along with surgeon experience. All analyses were performed with SAS 9.2 (SAS Institute Inc., Cary, NC, USA).

3. Results

Over the study period, subjects increasingly presented with better baseline sexual function ($p = 0.004$) and lower body mass index ($p = 0.007$); however, other demographic and tumor characteristics did not differ (Table 1). In terms of intraoperative characteristics, there was greater trainee participation at the robotic console during nerve sparing with increasing surgeon experience ($p < 0.001$). However, there was no variation in use of bilateral nerve sparing compared with unilateral nerve sparing and non–nerve sparing, number of positive surgical margins, and pathologic stage and grade.

In unadjusted analysis, 5-mo sexual function improved with greater surgeon experience ($p = 0.011$), with a range of 20.2 points and a 17.9-point increase from the first to last 50 men (Table 2). Similarly, 5-mo potency improved ($p = 0.008$), with a range of 33.3%, increasing from 0% to 15.8% from the first to last 50 men. Additionally, there was improved 12-mo sexual function with greater surgeon experience ($p = 0.030$), with a range of 21.8 and a 17.8-point increase from the first to last 50 men; there was parallel improvement in 12-mo potency ($p = 0.010$), with a range of 44.5%, increasing from 14.8% to 31.3% from the first to last 50 men.

In adjusted analyses (Table 3), greater surgeon experience was associated with better 5-mo sexual function (parameter estimate [PE]: 5.21; 95% confidence interval [CI], 1.4–9.02) and with a trend for better 12-mo sexual function (PE: 0.06; 95% CI, 0–0.12). Additionally, trainee robotic console involvement during nerve sparing was associated with worse 12-mo sexual function (PE: −12.58; 95% CI, −23.23 to −1.92). Older patient age was associated with worse 5-mo sexual function (PE: −0.49; 95% CI, −0.09 to −0.08) and worse12-mo sexual function (PE: −0.72; 95% CI, −1.25 to −0.19). Conversely, better baseline sexual function was associated with better 5-mo sexual function (PE: 0.31; 95% CI, 0.21–0.40) and better 12-mo sexual function (PE: 0.40; 95% CI, 0.27–0.52). Finally, non–nerve sparing/unilateral nerve sparing versus bilateral nerve sparing was associated with worse 5-mo sexual function (PE: −9.90; 95% CI, −17.27 to −2.53). Five-month and 12-mo unadjusted and adjusted mean sexual function performance curves are presented in Figures 5 and 6, respectively.

4. Discussion

The detrimental effect of neural stretch injury has been quantified in other surgical fields. Wall et al. demonstrated that a 6% nerve stretch may result in a 70% reduction of

Table 2 – Sexual function outcomes by sequential groups of 50 subjects

	1–50	51–100	101–150	151–200	201–250	251–300	301–350	351–400	*p* value
EPIC sexual function									
mean ± standard deviation									
5 mo, *n*	43	47	42	47	46	47	47	46	
	14.6 ± 17.9	22.2 ± 21.6	26.5 ± 19.6	28.7 ± 22.7	31.2 ± 31.4	34.8 ± 33.7	30.2 ± 29.1	32.5 ± 31.4	0.011
12 mo, *n*	45	45	46	45	42	31	–	–	
	26.7 ± 18.6	28.5 ± 19.7	29.0 ± 22.1	33.3 ± 23.9	48.5 ± 36.9	44.5 ± 32.0	–	–	0.030
Potency in previously potent, *n* (%)									
5 mo	0 (0.0)	3 (10.7)	2 (6.5)	4 (11.1)	10 (33.3)	10 (27.8)	6 (19.4)	6 (15.8)	0.008
12 mo	4 (14.8)	7 (26.9)	6 (17.1)	10 (28.6)	16 (59.3)	10 (31.3)			0.010

EPIC = Expanded Prostate Cancer Index Composite.

Table 3 – Multivariable analysis of factors associated with 5- and 12-mo sexual function

Covariates (referent)	5-mo sexual function	*p* value	12-mo sexual function	*p* value
Surgeon experience, PE (95% CI)*	5.21 (1.40–9.02)	0.007	0.06 (0.00–0.12)	0.061
Trainee robotic console nerve-sparing participation, PE (95% CI)	−1.80 (−8.16 to 4.55)	0.577	−12.58 (−23.23 to −1.92)	0.021
Non–nerve sparing/unilateral nerve sparing (bilateral), PE (95% CI)	−9.90 (−17.27 to −2.53)	0.009	−7.49 (−16.90 to 1.92)	0.120
Age, PE (95% CI)	−0.49 (−0.90 to −0.08)	0.019	−0.72 (−1.25 to −0.19)	0.018
Baseline sexual function, PE (95% CI)	0.31 (0.21–0.40)	<0.001	0.40 (0.27–0.52)	<0.001
Assistant surgeon training (PGY6), PE (95% CI)				
PGY2	−2.35 (−13.21 to 8.51)	0.670	4.21 (−8.00 to 16.42)	0.498
PGY3	−4.40 (−12.61 to 3.81)	0.292	−1.62 (−11.22 to 7.98)	0.740
PGY5	−1.18 (−8.80 to 6.44)	0.761	2.58 (−9.80 to 14.95)	0.682

PE = parameter estimate; CI = confidence interval; PGY = postgraduate year.

* Modeled as a logarithmic and linear term at 5 and 12 mo, respectively.

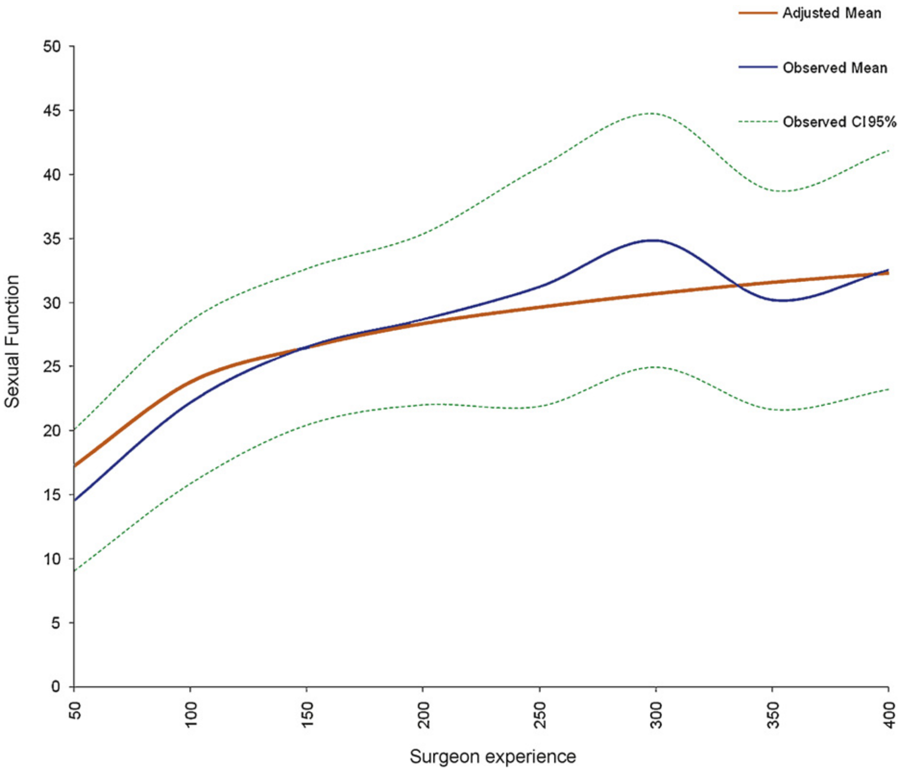


Fig. 5 – Improved 5-mo postprostatectomy sexual function associated with transition from blunt to predominately sharp neurovascular bundle dissection with minimization of lateral neurovascular bundle displacement; adjusted curve controls for surgeon experience, trainee nerve-sparing participation, non–nerve sparing/unilateral nerve sparing compared with bilateral nerve sparing, patient age, and baseline sexual function.

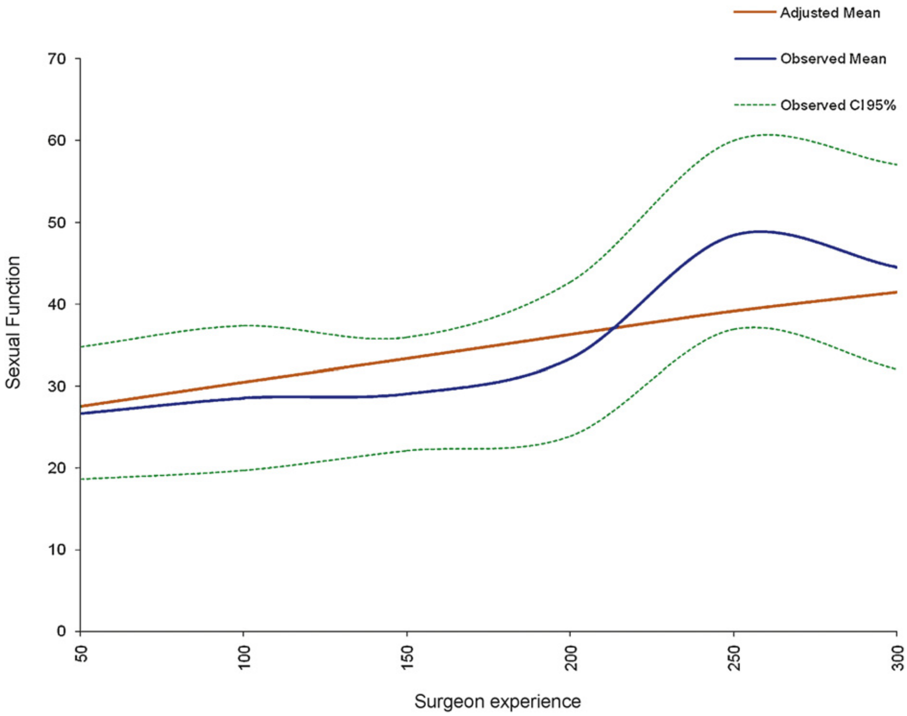


Fig. 6 – Improved 12-mo postprostatectomy sexual function associated with transition from blunt to predominately sharp neurovascular bundle dissection with minimization of lateral neurovascular bundle displacement; adjusted curve controls for surgeon experience, trainee nerve-sparing participation, non–nerve sparing/unilateral nerve sparing compared with bilateral nerve sparing, patient age, and baseline sexual function.

action potentials, and a 12% nerve stretch for more than an hour resulted in indefinite complete loss of nerve conduction [18]. For instance, accessory nerve traction during head and neck surgery leads to postoperative shoulder disability [19]. For radical prostatectomy, the detrimental effect of neurovascular bundle stretch injury has been mentioned [20–24], and we previously quantified the earlier recovery of sexual function with avoidance of continuous assistant/surgeon countertraction of the neurovascular bundle [15].

Our study has several important findings. First, we demonstrate additional technical refinements to minimize lateral displacement of the neurovascular bundle, resulting in earlier and better recovery of sexual function. Comparison of the first and last 50 men reveals an improvement of approximately 18 points at both 5 and 12 mo after prostatectomy. This finding is both statistically and clinically significant, as a minimally important difference of 10–12 points in the EPIC sexual function scale is of clinical significance [25]. Additionally, younger patient age and better baseline sexual function are associated with better post-prostatectomy sexual function, as demonstrated by others [3].

Second, we quantify a learning curve and demonstrate technical modifications for improved recovery of sexual function that includes 413 RARPs to consistently achieve the nerve-sparing dissection plane, 268 RARPs to become independent of continuous countertraction to facilitate nerve-sparing dissection, and 400 RARPs to attenuate transient lateral displacement of the neurovascular bundle [15]. While RARP learning curves have been characterized for reducing operating time, blood loss, and positive surgical margins and for improving urinary continence, no studies have demonstrated a learning curve for improving sexual function [26]. In fact, Zorn et al. demonstrated improvement in the previously mentioned metrics over 700 RARPs without a change in sexual function outcomes [26]. While Vickers et al. contend that outcomes improve with greater surgeon experience and illustrate the potential pitfall of concluding that there is significant improvement following the implementation of a new technique [27], it is unclear what specific modifications may contribute to continuous improvement of outcomes. Conversely, our video and corresponding outcomes demonstrate that subtle refinement in surgical technique typically occurs gradually over time, in contrast to analyses that dichotomize pretechnique modification and post-technique modification. Moreover, while many learning curve papers pronounce a volume threshold beyond which outcomes improve, few describe specific technical modifications associated with better outcomes during mastery of the learning curve.

Third, trainee robotic console involvement during nerve sparing was associated with worse 12-mo sexual function despite explicit intraoperative instruction, underscoring the learning curve for optimizing recovery of sexual function, and this finding has implications for training during RARP. We did not have a dual-console robotic system, which facilitates attending surgeon intercession. Additionally, selecting men with baseline erectile dysfunction when allowing trainee participation during nerve sparing may maximize sexual function outcomes, which contrasts with prior studies that did not demonstrate a negative impact of trainee robotic console involvement on other outcomes, such as operative time, estimated blood loss, and number of positive surgical margins [28,29]. Our findings also highlight a need for robotic surgery simulator development to improve RARP sexual function outcomes by quantifying and reducing instrument excursion during blunt dissection and resultant neurovascular bundle displacement. Moreover, longer follow-up is needed to characterize the effect of trainee RARP nerve-sparing involvement on long-term sexual function outcomes.

Our study must be considered within the context of the study design. First, although data were prospectively collected, this is a single-surgeon retrospective study subject to inherent biases rather than a randomized controlled trial. However, surgical randomized controlled trials are difficult to implement, as surgeons become biased to certain techniques with more experience, and there is difficulty in achieving investigator and patient equipoise. Moreover, multisurgeon randomized controlled trials are limited because of heterogeneity in surgical technique; however, we used third-party collection of self-reported quality-of-life outcomes with validated instruments. Second, aside from review of intraoperative video, current technology does not allow quantification of the degree of neurovascular bundle stretch. However, real-time quantification of achieving the optimal nerve-sparing dissection plane is similarly limited to intraoperative surgeon subjectivity, without postoperative histologic examination. Third, while our technical modification over several hundred RARPs improved sexual function outcomes, this threshold may be shorter for others who are emphatic about avoiding neurovascular bundle stretch. Finally, additional follow-up is needed to assess long-term sexual function, as recovery plateaus at or beyond 24 mo after prostatectomy [30].

5. Conclusions

Intermittent stretch of the neurovascular bundle when peeling off the neurovascular bundle results in delayed or diminished sexual function following RARP. Subtle technical refinement to attenuate lateral displacement of the neurovascular bundle and resultant stretch neuropathy improves sexual function within 12 mo of RARP.

Author contributions: J.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, Duclos.
Acquisition of data: Alemozaffar, Borza, Yu, Kowalczyk.
Analysis and interpretation of data: Lipsitz, Hevelone, Hu, Duclos.
Drafting of the manuscript: Hu, Alemozaffar, Kowalczyk, Duclos.
Critical revision of the manuscript for important intellectual content: Hu, Lipsitz, Alemozaffar.
Statistical analysis: Duclos, Hevelone, Lipsitz.
Obtaining funding: Hu.
Administrative, technical, or material support: Hu.

Supervision: Hu.
Other (specify): None.

Financial disclosures: I certify that all conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript (eg, employment/affiliation, grants or funding, consultancies, honoraria, stock ownership or options, expert testimony, royalties, or patents filed, received, or pending), are the following: H.Y. Yu receives salary support from the Robert and Kathy Salipante Minimally Invasive Urologic Oncology Fellowship. J.C. Hu receives salary support from US Department of Defense Physician Training Award W81XWH-08-1-0283.

Funding/Support and role of the sponsor: None.

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.2012.02.053 and via www.europeanurology.com.

References

[1] McNaughton-Collins M, Fowler Jr FJ, Caubet JF, et al. Psychological effects of a suspicious prostate cancer screening test followed by a benign biopsy result. Am J Med 2004;117:719–25.

[2] Welch HG, Black WC. Overdiagnosis in cancer. J Natl Cancer Inst 2010;102:605–13.

[3] Alemozaffar M, Regan MM, Cooperberg MR, et al. Prediction of erectile function following treatment for prostate cancer. JAMA 2011;306:1205–14.

[4] Johansson E, Bill-Axelson A, Holmberg L, Onelöv E, Johansson J-E, Steineck G, for the Scandinavian Prostate Cancer Group Study No 4. Time, symptom burden, androgen deprivation, and self-assessed quality of life after radical prostatectomy or watchful waiting: the Randomized Scandinavian Prostate Cancer Group study number 4 (SPCG-4) clinical trial. Eur Urol 2009;55:422–32.

[5] Schroeck FR, Krupski TL, Sun L, et al. Satisfaction and regret after open retropubic or robot-assisted laparoscopic radical prostatectomy. Eur Urol 2008;54:785–93.

[6] Sanda MG, Dunn RL, Michalski J, et al. Quality of life and satisfaction with outcome among prostate-cancer survivors. New Engl J Med 2008;358:1250–61.

[7] Krupski T, Saigal C, Litwin M. Variation in continence and potency by definition. J Urol 2003;170:1291–4.

[8] Vickers A, Savage C, Bianco F, et al. Cancer control and functional outcomes after radical prostatectomy as markers of surgical quality: analysis of heterogeneity between surgeons at a single cancer center. Eur Urol 2011;59:317–22.

[9] Walsh PC. Anatomic radical prostatectomy: evolution of the surgical technique. J Urol 1998;160:2418–24.

[10] Zorn KC, Gofrit ON, Orvieto MA, Mikhail AA, Zagaja GP, Shalhav AL. Robotic-assisted laparoscopic prostatectomy: functional and pathologic outcomes with interfascial nerve preservation. Eur Urol 2007; 51:755–63, discussion 763.

[11] Rassweiler J. Intrafascial nerve-sparing laproscopic radical prostatectomy: do we really preserve relevant nerve-fibres? Eur Urol 2006;49:955–7.

[12] Stolzenburg J-U, Rabenalt R, Do M, et al. Intrafascial nerve-sparing endoscopic extraperitoneal radical prostatectomy. Eur Urol 2008; 53:931–40.

[13] Bradford TJ, Weizer AZ, Gilbert SM, et al. Is residual neurovascular tissue on prostatectomy specimens associated with surgeon intent at nerve-sparing and postoperative quality of life measures? Urol Oncol 2010;28:487–91.

[14] Schatloff O, Chauhan S, Sivaraman A, Kameh D, Palmer KJ, Patel VR. Anatomic grading of nerve sparing during robot-assisted radical prostatectomy. Eur Urol 2012;61:796–802.

[15] Kowalczyk KJ, Huang AC, Hevelone ND, et al. Stepwise approach for nerve sparing without countertraction during robot-assisted radical prostatectomy: technique and outcomes. Eur Urol 2011; 60:536–47.

[16] Wei JT, Dunn RL, Litwin MS, Sandler HM, Sanda MG. Development and validation of the Expanded Prostate Cancer Index Composite (EPIC) for comprehensive assessment of health-related quality of life in men with prostate cancer. Urology 2000;56:899–905.

[17] Ramsay CR, Grant AM, Wallace SA, Garthwaite PH, Monk AF, Russell IT. Statistical assessment of the learning curves of health technologies. Health Technol Assess 2001;5:1–79.

[18] Wall E, Massie J, Kwan M, Rydevik B, Myers R, Garfin S. Experimental stretch neuropathy: changes in nerve conduction under tension. J Bone Joint Surg Br 1992;74:126–9.

[19] Erisen L, Basel B, Irdesel J, et al. Shoulder function after accessory nerve–sparing neck dissections. Head Neck 2004;26:967–71.

[20] Mulhall JP, Slovick R, Hotaling J, et al. Erectile dysfunction after radical prostatectomy: hemodynamic profiles and their correlation with the recovery of erectile function. J Urol 2002;167:1371–5.

[21] Kaul S, Savera A, Badani K, Fumo M, Bhandari A, Menon M. Functional outcomes and oncological efficacy of Vattikuti Institute prostatectomy with veil of Aphrodite nerve sparing: an analysis of 154 consecutive patients. BJU Int 2006;97:467–72.

[22] Mattei A, Naspro R, Annino F, Burke D, Guida Jr R, Gaston R. Tension and energy-free robotic-assisted laparoscopic radical prostatectomy with interfascial dissection of the neurovascular bundles. Eur Urol 2007;52:687–95.

[23] Rassweiler J, Wagner AA, Moazin M, et al. Anatomic nerve-sparing laparoscopic radical prostatectomy: comparison of retrograde and antegrade techniques. Urology 2006;68:587–91.

[24] Zorn KC, Gofrit ON, Orvieto MA, Mikhail AA, Zagaja GP, Shalhav AL. Robotic-assisted laparoscopic prostatectomy: functional and pathologic outcomes with interfascial nerve preservation. Eur Urol 2007; 51:755–63.

[25] Dunn RLSM, Wei JT. Minimally important difference for the Expanded Prostate Cancer Index Composite. LA: New Orleans; 2009.

[26] Zorn KC, Wille MA, Thong AE, et al. Continued improvement of perioperative, pathological and continence outcomes during 700 robot-assisted radical prostatectomies. Can J Urol 2009;16:4742–9, discussion 4749.

[27] Vickers AJ, Cronin AM, Masterson TA, Eastham JA. How do you tell whether a change in surgical technique leads to a change in outcome? J Urol 2010;183:1510–4.

[28] Schroeck FR, de Sousa CA, Kalman RA, et al. Trainees do not negatively impact the institutional learning curve for robotic prostatectomy as characterized by operative time, estimated blood loss, and positive surgical margin rate. Urology 2008;71: 597–601.

[29] Thiel DD, Francis P, Heckman MG, Winfield HN. Prospective evaluation of factors affecting operating time in a residency/fellowship training program incorporating robot-assisted laparoscopic prostatectomy. J Endourol 2008;22:1331–8.

[30] Litwin MS, Melmed GY, Nakazon T. Life after radical prostatectomy: a longitudinal study. J Urol 2001;166:587–92.

Stepwise Description and Outcomes of Bladder Neck Sparing During Robot-Assisted Laparoscopic Radical Prostatectomy

David F. Friedlander, Mehrdad Alemozaffar, Nathanael D. Hevelone, Stuart R. Lipsitz and Jim C. Hu*

From the Harvard School of Public Health (DFF), Division of Urologic Surgery (MA) and Center for Surgery and Public Health (NDH, SRL), Brigham and Women's Hospital, Boston, Massachusetts, and Department of Urology, David Geffen School of Medicine at University of California-Los Angeles (JCH), Los Angeles, California

Abbreviations and Acronyms

PSA = prostate specific antigen

RALP = robot-assisted radical prostatectomy

Submitted for publication March 20, 2012.

Study received institutional review board approval.

Support by Department of Defense Prostate Cancer Physician Training Award W81XWH-08-1-0283 (JCH).

Supplementary material for this article can be obtained at http://urology.ucla.edu/body.cfm?id=551.

* Correspondence: Department of Urology, David Geffen School of Medicine at University of California-Los Angeles, 924 Westwood Blvd., Los Angeles, California 90024 (telephone: 310-794-6168; FAX: 310-794-6789; e-mail: jimhumd@gmail.com).

For another article on a related topic see page 1957.

Purpose: While bladder neck sparing may improve post-prostatectomy urinary continence, there is concern that it may lead to more positive surgical margins and compromise cancer control. We compared the continence and cancer control outcomes of bladder neck sparing vs nonsparing techniques during robot-assisted laparoscopic radical prostatectomy.

Materials and Methods: Data were prospectively collected on 1,067 robot-assisted laparoscopic radical prostatectomies done from September 2005 through October 2011. We compared the procedures according to bladder neck sparing (791) and nonsparing (276). Continence was defined by zero pad responses on the EPIC (Expanded Prostate Cancer Index) item quantifying daily use. Biochemical recurrence was defined as prostate specific antigen 0.1 ng/ml or greater. Cox regression was performed to assess factors associated with post-prostatectomy continence and biochemical recurrence-free survival.

Results: Median followup for bladder neck sparing vs nonsparing was 25.8 vs 51.7 months. Men treated with bladder neck sparing were more likely to have clinical T1c tumors ($p < 0.001$) and less likely to have biopsy Gleason grade 6 or less disease ($p = 0.023$). They experienced fewer urinary leaks ($p = 0.009$) and shorter length of stay ($p = 0.006$). Regarding cancer control outcomes, there was no difference in bladder neck sparing vs nonsparing base (1.2% vs 2.6%, $p = 0.146$) and overall surgical margin positivity (each 13.8%, $p = 0.985$). On adjusted analyses bladder neck sparing vs nonsparing was associated with better continence (HR 1.69, 95% CI 1.43–1.99) and similar biochemical recurrence-free survival (HR 1.20, 95% CI 0.62–2.31, $p = 0.596$).

Conclusions: Bladder neck sparing is associated with fewer urinary leak complications, shorter hospitalization and better post-prostatectomy continence without compromising cancer control compared to bladder neck nonsparing.

Key Words: prostate, prostatectomy, mortality, prostatic neoplasms, urinary incontinence

RADICAL prostatectomy remains the most popular definitive treatment for localized prostate cancer[1] and more than 75% of radical prostatectomies in the United States are currently performed robotically.[2] Post-prostatectomy urinary incontinence negatively impacts quality of life.[3] The likelihood of incontinence ranges between 2.5% and 87% depending on the definition of urinary control, collecting outcome methodology and surgical technique.[4]

Recovery of post-prostatectomy urinary function is multifactorial regard-

0022-5347/12/1885-1754/0
THE JOURNAL OF UROLOGY®

http://dx.doi.org/10.1016/j.juro.2012.07.045
Vol. 188, 1754-1760, November 2012
Printed in U.S.A.

less of open vs robot-assisted approaches. Patient characteristics associated with better continence include younger age,[5] better baseline urinary function and longer membranous urethral length.[1] Post-prostatectomy continence may also be improved by surgical technical factors, such as nerve sparing and apical dissection,[6,7] but the role of bladder neck sparing in urinary control recovery remains controversial.[8]

Opponents of preserving the internal urinary sphincter contend that cancer control may be compromised by dissection in close proximity to the prostate base.[9] Proponents of bladder neck sparing state that the 3-dimensional 12× magnification provided by the robotic surgical system enables differentiation between bladder neck fibers and prostate tissue.[2] Moreover, comparisons of functional and oncological outcomes between bladder neck sparing and nonsparing may be biased by heterogeneous techniques among surgeons and surgical series.[10,11]

In this prospective study we compared the perioperative continence and cancer control outcomes of bladder neck sparing vs nonsparing techniques during RALP.

MATERIALS AND METHODS

Surgical Technique

We have refined and streamlined our previously described bladder neck sparing technique.[9] Before bladder neck dissection we no longer preemptively suture ligate mid prostatic vessels coursing through the detrusor apron and potential back bleeders coursing through the anterior bladder wall proximal to the bladder. The fourth arm ProGrasp™ is used to grasp and tent the anterior bladder wall anteriorly to identify the junction of the bladder and prostate. Sharp dissection is performed here in the midline through the connective tissue of the detrusor apron until reaching bladder fibers. The use of monopolar current may obscure these fibers. Short bursts of bipolar cautery to minimize charring are used for hemostasis. Upon reaching bladder fibers, the curve of the prostate in the sagittal plane is followed proximally to the bladder neck. The incision is extended lateral in arced fashion to avoid vessels that course from the prostate lateral pedicle to the dorsal vascular complex (fig. 1, *A*).

Blunt dissection is then performed in a caudal direction over the anterior bladder neck to identify the vertical fibers of the prostatic urethra. Blunt dissection is done lateral to the bladder neck on each side by opening the Maryland dissector and pushing the scissors caudal, resulting in a triangular spread bilaterally on the lateral lobes of the prostate and defining the funneled shape of the bladder neck transitioning to the prostatic urethra (fig. 1, *B*). The bladder neck is opened anterior, the urethral catheter is withdrawn after deflating the balloon and the posterior bladder mucosa is incised with monopolar current (fig. 2). This creates a foothold to grasp the prostatic urethra/base and elevate the prostate. Doing so obviates the need for assistant surgeon catheter manipulation to elevate the prostate. Assistant counter traction is applied on the bladder neck and dissection proceeds posterior to the detrusor apron (fig. 3, *A*). Dissection then continues laterally to the adipose tissue that defines the lateral border of dissection (fig. 3, *B*). The detrusor apron is opened as low as possible, revealing the vas deferens (fig. 3, *C*).

Data

In this institutional review board approved study we prospectively collected data on 1,067 RALPs performed by one of us (JCH) from September 2005 through October 2011. We dichotomized based on bladder neck sparing vs nonsparing. Patients with bladder neck sparing had a bladder neck circumference that approximated the urethral stump before anastomosis, while those with bladder neck nonsparing required bladder neck reconstruction/tapering before anastomosis. Bladder neck sparing was attempted during RALP regardless of prostate cancer

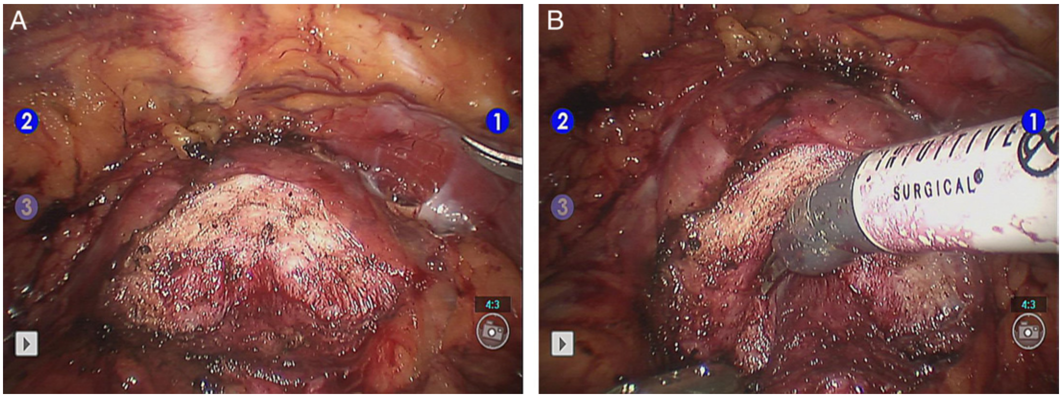


Figure 1. Bladder neck dissection is initiated in midline at prostate mid/base anterior until reaching depth of vertically oriented bladder neck fibers (*A*). Bladder neck incision is arced cephalad with lateral extension until anterior portion of bladder neck is defined. Blunt dissection is performed anterior, and on right and left (*B*) of bladder neck to define its funneled contour as it transitions to prostatic urethra.

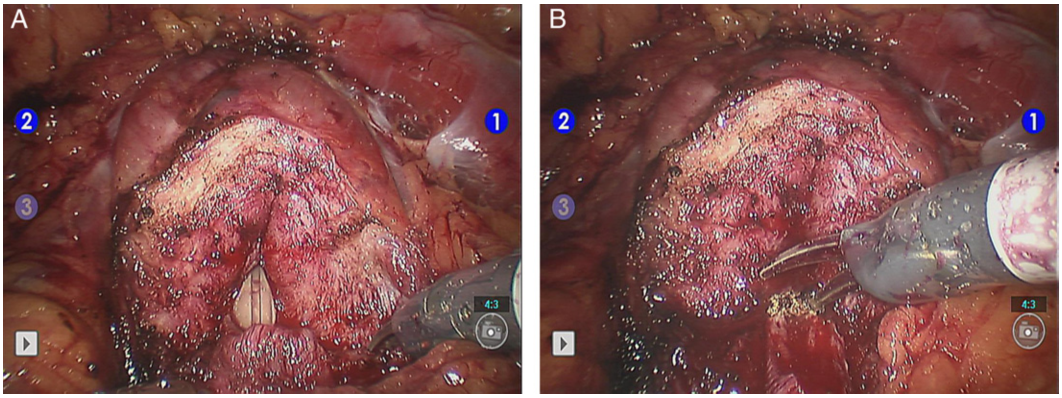


Figure 2. Bladder neck is opened anterior to expose catheter (*A*), which is withdrawn before scoring posterior bladder neck mucosa with monopolar current (*B*).

biopsy characteristics. However, the ability to perform bladder neck sparing improved with greater experience and was achieved with greater frequency later in the series.[9]

Men with pathological features such as positive surgical margins, and/or pathological T3a and T3b disease were counseled on the risks and benefits of adjuvant radiotherapy. The 64 men who elected adjuvant therapy were censored from subsequent assessment of continence and biochemical recurrence-free survival, defined as PSA 0.1 ng/ml or greater. The 93 men who experienced biochemical recurrence were counseled on salvage radiotherapy and 59 were censored from continence assessment only after receiving salvage therapy.

Outcomes

Responses to the EPIC[3] item that assesses daily pad use were dichotomized to 0 vs 1 or more pads to define continence vs incontinence. Urine leak was defined as 1) high drain output with creatinine greater than serum levels or 2) anastomotic contrast medium extravasation on cystography.

Statistical Analysis

All clinical data and EPIC responses were prospectively collected by research personnel uninvolved with clinical care and entered into Microsoft® Access®. Univariable analyses of continuous and categorical variables were performed with the t and chi-square tests, respectively. Multivariable analysis with Cox regression was performed a priori with covariates associated with continence recovery, such as patient age, baseline urinary function, nerve sparing type (bilateral vs unilateral/nonnerve sparing) and bladder neck sparing vs nonsparing. Similarly, Cox regression analysis was done a priori with covariates associated with biochemical recurrence, such as preoperative PSA, surgical margin status, pathological Gleason grade and stage, and bladder neck sparing vs nonsparing. Statistical analyses were performed with SAS® 9.2.

RESULTS

Median followup for bladder neck sparing in 791 men vs nonsparing in 276 was 25.8 vs 51.7 months.

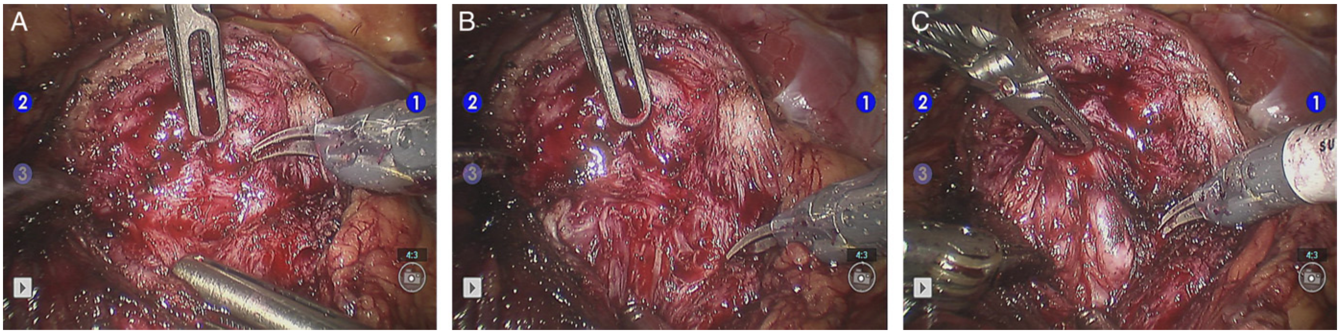


Figure 3. Fourth arm ProGrasp elevates prostate base to create tension for posterior bladder neck dissection (*A*). Assistant laparoscopic grasper counter traction is applied during posterior bladder neck dissection. Bladder neck dissection proceeds laterally to adipose tissue, which serves as lateral border of dissection bilaterally (*B*). Downward traction of assistant suction tip aids exposure. Note suction tip on posterior longitudinal detrusor layer. Posterior longitudinal detrusor layer is opened as low as possible, revealing vas deferens (*C*).

Demographics, tumor biopsy characteristics, intraoperative data, and pathological and perioperative outcomes

	Bladder Neck Sparing	Bladder Neck Nonsparing	p Value
No. pts	791	276	
Mean ± SD age	58.9 ± 6.6	58.8 ± 6.8	0.917
No. race (%):			
White	732 (92.5)	253 (91.7)	
Black	33 (4.2)	12 (4.4)	
Other	26 (3.3)	11 (4.0)	0.852
Mean ± SD preop urinary function score	96.2 ± 10.9	95.2 ± 12.1	0.201
Mean ± SD PSA (ng/ml)	5.6 ± 3.4	5.9 ± 5.2	0.503
No. clinical stage T1c (%)	744 (94.1)	237 (85.9)	<0.001
No. Gleason grade (%):			
6 or Less	437 (55.2)	180 (65.2)	
7	313 (39.6)	83 (30.1)	
8 or Greater	41 (5.2)	13 (4.7)	0.014
No. pathological Gleason grade (%):			
6 or Less	275 (34.8)	131 (47.5)	
7	479 (60.6)	125 (45.3)	
8 or Greater	37 (4.6)	20 (7.2)	<0.001
No. pathological stage (%):			
pT0	4 (0.5)	4 (1.5)	
pT2	669 (84.6)	233 (84.4)	
pT3a	88 (11.1)	29 (10.5)	
pT3b	30 (3.8)	10 (3.6)	0.301
No. pos surgical margins (%):			
Base	9 (1.1)	7 (2.5)	0.146 (Fisher exact test)
Overall	109 (13.8)	38 (13.8)	0.985
No. nerve sparing technique (%):			
None/unilat	148 (18.7)	51 (18.5)	
Bilat	643 (81.3)	225 (81.5)	0.918
Mean ± SD length of stay (days)	1.1 ± 0.6	1.3 ± 1.1	0.006
Mean ± SD catheterization (days)	7.9 ± 3.5	8.0 ± 3.5	0.924
No. urine leak (%)	11 (1.4)	11 (4.0)	0.009

While demographic and biopsy tumor characteristics as well as baseline urinary function were similar (see table), men treated with bladder neck sparing were more likely to have clinical stage T1c tumors (94.2% vs 85.9%, p <0.001) but less likely to have biopsy Gleason grade 3 + 3 = 6 or less disease (55.2% vs 65.2%, p = 0.023).

In terms of operative outcomes for bladder neck sparing vs nonsparing (see table), the frequency of the bilateral vs the unilateral/nonnerve sparing technique did not vary by bladder neck sparing vs nonsparing. Men with bladder neck sparing experienced fewer urinary leak complications (1.4% vs 4.0%, p = 0.009) and shorter length of stay (1.1 vs 1.3 days, p = 0.006). With respect to cancer control outcomes (see table), there was no significant difference in bladder neck sparing vs nonsparing base (1.1% vs 2.5%, p = 0.146) or overall (each 13.8%, p = 0.985) surgical margin positivity. Similarly, there was no difference in biochemical recurrence-free survival rates for bladder neck sparing vs nonsparing after controlling for pathological stage, grade, baseline PSA and margin status (HR 1.20, 95% CI 0.62–2.31, p = 0.596, fig. 4). However, bladder neck sparing vs nonsparing was associated with earlier and better recovery of continence (HR 1.69, 95% CI 1.43–1.99, p <0.001, fig. 5).

DISCUSSION

As knowledge of pelvic anatomy has improved, various surgical technical modifications have emerged that are intended to preserve critical structures, such as the neurovascular bundle and external urethral sphincter muscle. However, controversy exists over whether dissecting the bladder neck vs the nerve sparing plane to preserve the bladder neck/internal sphincter comprises anatomical radical prostatectomy.[12] While RALP has been rapidly adopted and offers several advantages, such as greater magnification and less blood loss, prior research showed that men who undergo RALP are more likely to be diagnosed with incontinence. However, bladder neck sparing was not considered in these studies. Subsequent research revealed that bladder neck sparing vs nonsparing is associated with earlier recovery of continence within a year of RALP.[4,9]

The absence of tactile feedback may account for bladder neck dissection being regarded as one of the most challenging steps of RALP.[13] In fact, the inability to palpate during RALP represents one of the most challenging steps for those early in the learning curve.[14,15] Counterintuitively, while other RALP steps decrease in complexity during the first 50 cases, the requisite time for bladder neck dissection increases.[16] Consequently, bladder neck sparing during RALP may contribute to a greater likelihood of residual prostate tissue and eventual biochemical recurrence.

Our study has several important findings. 1) Bladder neck sparing was associated with quicker return of continence and better long-term continence than nonbladder neck sparing, as evidenced by better bladder neck sparing vs nonsparing continence throughout followup. These results are consistent with those of prior studies demonstrating better early continence for bladder neck sparing during RALP[4,9] and open radical prostatectomy.[17–19] In contrast to Freire et al, who found no difference in 24-month continence rates between men with bladder neck sparing and nonsparing,[9] our study has greater long-term followup for examining long-term continence outcomes.

2) Bladder neck sparing was not associated with worse cancer control, as demonstrated by similar overall and prostate base surgical margin status and biochemical recurrence-free survival between men with bladder neck sparing and nonsparing. Our 1, 3 and 5-year biochemical recurrence-free survival

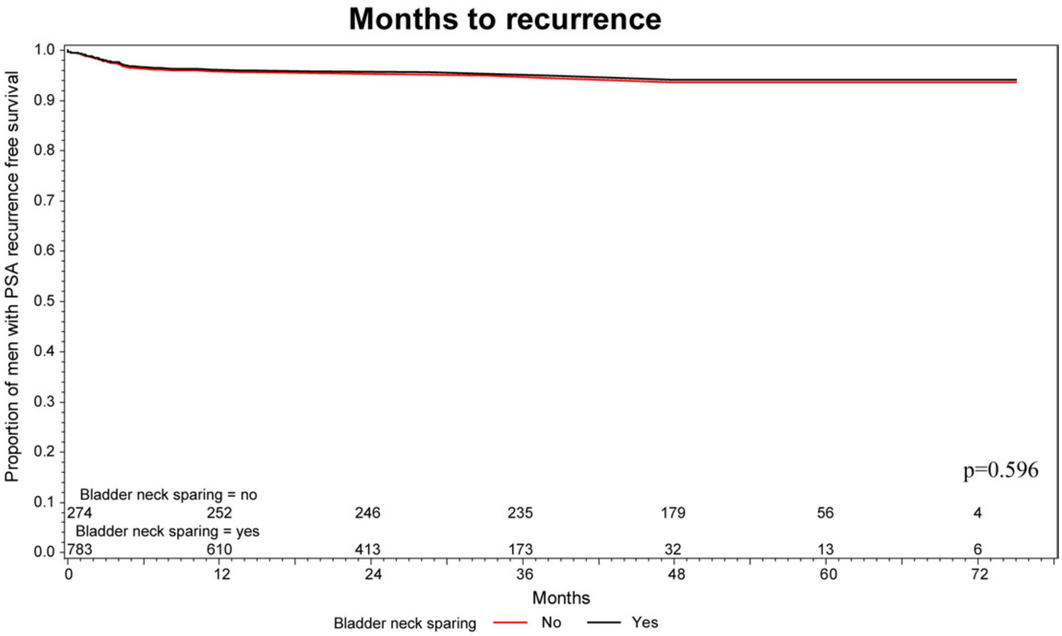


Figure 4. After adjusting for PSA, surgical margin status, and pathological grade and stage, biochemical recurrence-free survival was similar in bladder neck sparing and nonsparing cohorts (p = 0.596).

rates are similar to those reported by Menon et al.[20] While we noted no difference in surgical margin status for bladder neck sparing vs nonsparing, similar to Shelfo et al,[21] and Soloway and Neulander,[22] this finding contrasts with earlier studies demonstrating a greater likelihood of positive prostate base margins[23–25] and worse cancer control[8] in the setting of bladder neck sparing during open and laparoscopic radical prostatectomy. This may be due to heterogeneity in bladder neck dissection tech-

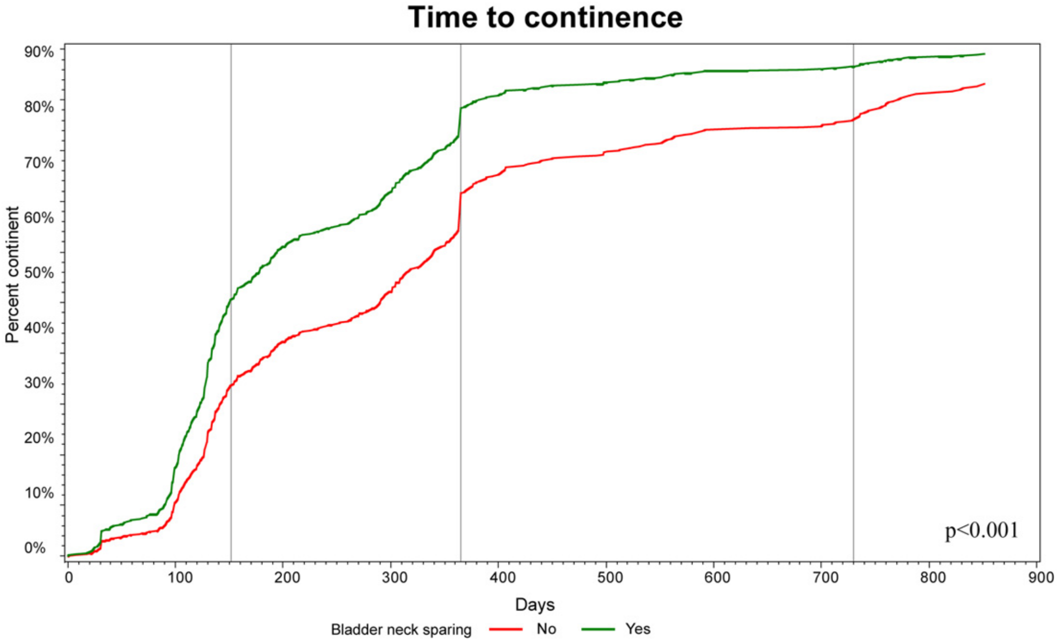


Figure 5. Better urinary continence for bladder neck sparing vs nonsparing (HR 1.69, 1.43–1.99 95% CI). Vertical lines represent 5 (HR 1.43, 1.10–1.85 95% CI, p = 0.008), 12 (HR 1.29, 95% CI 1.08–1.55, p = 0.005) and 24-month (HR 1.18, 95% CI 1.00–1.40, p = 0.048) followup, demonstrating better continence with bladder neck sparing at these followup intervals (p values adjusted for multiple comparisons).

niques coupled with variations in surgical approach, ie robotic vs open.

3) Bladder neck sparing was associated with fewer urinary leak complications and shorter length of stay, consistent with existing RALP literature comparing urinary leak and/or length of stay in bladder neck sparing vs nonsparing cases.[9,26] The shorter anastomotic suture line associated with bladder neck sparing likely heals more quickly and is less susceptible to urine leak. The greater frequency of urine leaks and accompanying peritonitis, and higher surgical drain output observed with nonbladder neck sparing vs bladder neck sparing may contribute to the greater variation in length of stay. The greater likelihood of urinary leak with bladder neck nonsparing may not be as evident for open radical prostatectomy due to the traditionally longer length of catheterization and the extraperitoneal approach, which precludes ileus and peritonitis secondary to anastomotic urine leak.[27]

Our findings must be interpreted in the context of the study design. This was a retrospective, observational study, in contrast to a prospective, randomized control trial. Surgeon and patient equipoise is difficult to achieve, particularly if the surgeon is biased toward bladder neck sparing, which obviates the need for bladder neck reconstruction and leads to shorter operative time. Moreover, bladder neck sparing is a technique that was used with greater frequency later in our surgical experience,[9] which also corresponded with performing RALP in men with higher biopsy and pathological Gleason grades. However, we adjusted for preoperative PSA, pathological grade and other characteristics when comparing biochemical recurrence-free survival. The definition of continence varies across studies. However, we report continence and pad use from a validated, patient self-reported quality of life instrument with third party data collection, similar to that in other large radical prostatectomy series.[28,29] Furthermore, any pad use, even for safety or social confidence, was categorized as incontinence. Finally, longer followup is needed to compare biochemical recurrence-free survival for bladder neck sparing vs nonsparing.

CONCLUSIONS

Bladder neck sparing vs nonsparing is associated with earlier and better continence without worsening short-term cancer control. Moreover, bladder neck sparing is associated with fewer urine leaks and shorter RALP hospitalization.

REFERENCES

1. Cooperberg MR, Broering JM and Carroll PR: Time trends and local variation in primary treatment of localized prostate cancer. J Clin Oncol 2010; **28:** 1117.
2. Guru KA, Hussain A, Chandrasekhar R et al: Current status of robot-assisted surgery in urology: a multi-national survey of 297 urologic surgeons. Can J Urol 2009; **16:** 4736.
3. Sanda MG, Dunn RL, Michalski J et al: Quality of life and satisfaction with outcome among prostate-cancer survivors. N Engl J Med 2008; **358:** 1250.
4. Choi WW, Freire MP, Soukup JR et al: Nerve-sparing technique and urinary control after robot-assisted laparoscopic prostatectomy. World J Urol 2011; **29:** 21.
5. Eastham JA, Kattan MW, Rogers E et al: Risk factors for urinary incontinence after radical prostatectomy. J Urol 1996; **156:** 1707.
6. Poore RE, McCullough DL and Jarow JP: Puboprostatic ligament sparing improves urinary continence after radical retropubic prostatectomy. Urology 1998; **51:** 67.
7. Cambio AJ and Evans CP: Minimising postoperative incontinence following radical prostatectomy: considerations and evidence. Eur Urol 2006; **50:** 903.
8. Aydin H, Tsuzuki T, Hernandez D et al: Positive proximal (bladder neck) margin at radical prostatectomy confers greater risk of biochemical progression. Urology 2004; **64:** 551.
9. Freire MP, Weinberg AC, Lei Y et al: Anatomic bladder neck preservation during robotic-assisted laparoscopic radical prostatectomy: description of technique and outcomes. Eur Urol 2009; **56:** 972.
10. Hu JC, Wang Q, Pashos CL et al: Utilization and outcomes of minimally invasive radical prostatectomy. J Clin Oncol 2008; **26:** 2278.
11. Stolzenburg J, Schwalenberg T, Horn L et al: Anatomical landmarks of radical prostatectomy. Eur Urol 2007; **51:** 629.
12. Walsh PC: Anatomic radical prostatectomy: evolution of the surgical technique. J Urol 1998; **160:** 2418.
13. Ahlering TE, Skarecky D, Lee D et al: Successful transfer of open surgical skills to a laparoscopic environment using a robotic interface: initial experience with laparoscopic radical prostatectomy. J Urol 2003; **170:** 1738.
14. Tewari AK and Rao SR: Anatomical foundations and surgical manoeuvres for precise identification of the prostatovesical junction during robotic radical prostatectomy. BJU Int 2006; **98:** 833.
15. Bird VG, Reese J and Winfield HN: Identification and dissection of bladder neck during laparoscopic radical prostatectomy. Urology 2002; **60:** 680.
16. Thiel DD, Francis P, Heckman MG et al: Prospective evaluation of factors affecting operating time in a residency/fellowship training program incorporating robot-assisted laparoscopic prostatectomy. J Endourol 2008; **22:** 1331.
17. Deliveliotis C, Protogerou V, Alargof E et al: Radical prostatectomy: bladder neck preservation and puboprostatic ligament sparing—effects on continence and positive margins. Urology 2002; **60:** 855.
18. Lowe BA: Comparison of bladder neck preservation to bladder neck resection in maintaining postprostatectomy urinary continence. Urology 1996; **48:** 889.
19. Gaker DL and Steel BL: Radical prostatectomy with preservation of urinary continence: pathology and long-term results. J Urol 2004; **172:** 2549.
20. Menon M, Bhandari M, Gupta N et al: Biochemical recurrence following robot-assisted radical prostatectomy: analysis of 1384 patients with a median 5-year follow-up. Eur Urol 2010; **58:** 838.
21. Shelfo SW, Obek C and Soloway MS: Update on bladder neck preservation during radical retropu-

bic prostatectomy: impact on pathologic outcome, anastomotic strictures, and continence. Urology 1998; **51:** 73.

22. Soloway MS and Neulander E: Bladder-neck preservation during radical retropubic prostatectomy. Semin Urol Oncol 2000; **18:** 51.

23. Marcovich R, Wojno KJ, Wei JT et al: Bladder neck-sparing modification of radical prostatectomy adversely affects surgical margins in pathologic T3a prostate cancer. Urology 2000; **55:** 904.

24. Katz R, Salomon L, Hoznek A et al: Positive surgical margins in laparoscopic radical prostatectomy: the impact of apical dissection, bladder neck remodeling and nerve preservation. J Urol 2003; **169:** 2049.

25. Srougi M, Nesrallah LJ, Kauffmann JR et al: Urinary continence and pathological outcome after bladder neck preservation during radical retropubic prostatectomy: a randomized prospective trial. J Urol 2001; **165:** 815.

26. Asimakopoulos AD, Annino F, D'Orazio A et al: Complete periprostatic anatomy preservation during robot-assisted laparoscopic radical prostatectomy (RALP): the new pubovesical complex-sparing technique. Eur Urol 2010; **58:** 407.

27. Ficarra V, Novara G, Artibani W et al: Retropubic, laparoscopic, and robot-assisted radical prostatectomy: a systematic review and cumulative analysis of comparative studies. Eur Urol 2009; **55:** 1037.

28. Willis DL, Gonzalgo ML, Brotzman M et al: Comparison of outcomes between pure laparoscopic vs robot-assisted laparoscopic radical prostatectomy: a study of comparative effectiveness based upon validated quality of life outcomes. BJU Int 2012; **109:** 898.

29. Lepor H and Kaci L: The impact of open radical retropubic prostatectomy on continence and lower urinary tract symptoms: a prospective assessment using validated self-administered outcome instruments. J Urol 2004; **171:** 1216.

ELSEVIER

CrossMark

UROLOGIC ONCOLOGY

Urologic Oncology: Seminars and Original Investigations 34 (2016) 529.e1–529.e7

Original article

Technique and outcomes of bladder neck intussusception during robot-assisted laparoscopic prostatectomy: A parallel comparative trial

Hung-Jui Tan, M.D.[a,b], Siwei Xiong, M.D.[b], Aaron A. Laviana, M.D.[b], Ryan J. Chuang, B.S.[b], Eric Treat, M.D.[b], Patrick C. Walsh, M.D.[c], Jim C. Hu, M.D., M.P.H.[b,d,*]

[a] *VA/UCLA Robert Wood Johnson Clinical Scholars Program, University of California, Los Angeles, CA*
[b] *Department of Urology, University of California, Los Angeles, CA*
[c] *Brady Department of Urology, Johns Hopkins Medical Institute, Baltimore, MD*
[d] *Brady Department of Urology, Weill Cornell Medicine New York, New York*

Received 28 December 2014; received in revised form 14 January 2015; accepted 15 January 2015

Abstract

Introduction: Postprostatectomy incontinence significantly impairs quality of life. Although bladder neck intussusception has been reported to accelerate urinary recovery after open radical retropubic prostatectomy, its adaption to robotic surgery has not been assessed. Accordingly, we describe our technique and compare outcomes between men treated with and without bladder neck intussusception during robot-assisted laparoscopic prostatectomy.

Materials and methods: We performed a comparative trial of 48 men undergoing robot-assisted laparoscopic prostatectomy alternating between bladder neck intussusception ($n = 24$) and nonintussusception ($n = 24$). Intussusception was completed using 3-0 polyglycolic acid horizontal mattress sutures anterior and posterior to the bladder neck. We assessed baseline characteristics and clinicopathologic outcomes. Adjusting for age, body mass index, race, and D'Amico risk classification, we prospectively compared urinary function at 2 days, 2 weeks, 2 months, and last follow-up using the urinary domain of the Expanded Prostate Cancer Index—Short Form.

Results: Baseline patient characteristics and clinicopathologic outcomes were similar between treatment groups ($P > 0.05$). Median catheter duration (8 vs. 8 d, $P = 0.125$) and rates of major postoperative complications (4.2% vs. 4.2%, $P = 1.000$) did not differ. In adjusted analyses, Expanded Prostate Cancer Index—Short Form urinary scores were significantly higher for the intussusception arm at 2 weeks (65.4 vs. 46.6, $P = 0.019$) before converging at 2 months (69.1 vs. 68.3, $P = 0.929$) after catheter removal and at last follow-up (median = 7 mo, 80.5 vs. 77.0; $P = 0.665$).

Conclusions: Bladder neck intussusception during robot-assisted laparoscopic prostatectomy is feasible and safe. Although the long-term effects appear limited, intussusception may improve urinary function during the early recovery period.

Keywords: Comparative study; Incontinence; Prostatectomy; Prostate neoplasm

1. Introduction

Despite the widespread adoption of the robotic platform, rates of postprostatectomy incontinence continue to vary widely, affecting 4% to 31% of men over the long term and even more individuals during the early recovery period [1]. Postprostatectomy incontinence negatively affects patient satisfaction and quality of life, often leading to regret among men opting for radical prostatectomy as their treatment for prostate cancer [2]. Among those in need of definitive therapy, fear of temporary or lifelong urinary incontinence has led some men to bypass radical prostatectomy in favor of radiotherapy or newer therapies with limited long-term outcomes, such as high frequency intensity ultrasound or focal therapy with interstitial lasers. Additionally, urinary incontinence adds approximately \$5,477 in cost on a per person basis (adjusted for fiscal year 2013), highlighting both the financial- and health-related burden of this adverse outcome [3].

This research was supported by funding from the VA Office of Academic Affiliations through the VA/Robert Wood Johnson Clinical Scholars Program (H.T.) and by the National Institutes of Health Training, Grant no. T32-DK-07789 (E.T.).

[*] Corresponding author. Tel.: +212-746-4600; fax: +212-746-8396.
E-mail address: jch9011@med.cornell.edu (J.C. Hu).

http://dx.doi.org/10.1016/j.urolonc.2015.01.012
1078-1439/

Although multiple factors (e.g., age, body mass index, prostate volume, and surgeon inexperience) have been associated with postprostatectomy incontinence, several technical modifications have been shown to enhance urinary control following radical prostatectomy. For example, a randomized controlled trial demonstrated that bladder neck preservation reduces urinary leakage, improves social continence, and enhances quality of life. Even so, a significant number of men fail to achieve these results during the early recovery period (i.e., within 3 mo of radical prostatectomy) [1,4,5]. In 2002, Walsh and Marschke [6] described bladder neck intussusception, which improved 3-month continence rates from 54% to 82%, with equivalent continence rates at 1-year when compared with historical controls. Despite these promising results, subsequent findings have been mixed [7,8]. In fact, a recent review assessed athermal division and selective suture ligation of the dorsal vein complex, bladder neck preservation, and posterior reconstruction as beneficial in reducing postprostatectomy incontinence, but there was no mention of bladder neck intussusception as a technical modification to improve urinary control [1,5,9].

Therefore, the purpose of our study was to adapt bladder neck intussusception to the robotic platform and determine whether this technique improves short-term urinary outcomes. In this context, we performed a parallel, comparative trial, alternating men undergoing robot-assisted laparoscopic prostatectomy between bladder neck intussusception vs. nonintussusception (i.e., standard vesicourethral anastomosis).

2. Materials and methods

2.1. Study cohort and surgical technique

From August 2013 through April 2014, 48 men underwent robot-assisted laparoscopic radical prostatectomy consecutively by a single surgeon (J.C.H.) and underwent bladder neck intussusception vs. nonintussusception on an alternating basis. The planned procedure was discussed with each patient and informed consent obtained. To adapt the open technique to the robotic platform, the study surgeon reviewed online videos of open radical prostatectomy bladder neck intussusception and a higher definition version provided by Dr. Walsh [6,10]. Before study enrollment, 10 subjects underwent bladder neck intussusception with robot-assisted prostatectomy during a run-in period. Deidentified, video recordings were uploaded to YouTube and reviewed by Dr. Walsh, who provided critical feedback to improve surgical technique.

All subjects underwent prostate removal via robot-assisted laparoscopic prostatectomy, as described previously [9,11,12]. Using a 4-armed da Vinci Si Surgical System (Intuitive Surgical, Sunnyvale, CA), we performed an antegrade approach in the following order: (1) bladder neck and seminal vesicle dissection with bladder neck sparing, (2) antegrade nerve sparing, (3) pelvic lymph node dissection, (4) apical dissection, and (5) anastomosis.

To ensure optimal identification of the bladder neck during intussusception, we slightly modified our previously described anastomotic technique [13]. First, after placement of the initial 6-o'clock anastomotic suture in the urethral stump before division of the posterior apical prostatic urethra, a stay suture is placed at the 6-o'clock position in the bladder neck. This aids in the identification of the bladder neck, as it often retracts during intussusception.

Next, a 3-0 polyglycolic horizontal mattress suture is placed in the perivesical fat at the edges of the posterior bladder wall where the bladder was previously attached to the prostate and then tied down completely (Fig. 1). Following posterior intussusception, the stay suture at the bladder neck is removed. The vesicourethral anastomosis is then completed in our customary manner using 3 posterior interrupted and 2 running 3-0 polyglycolic sutures that meet and are tied together at the 12-o'clock position. Finally, another 3-0 polyglycolic horizontal mattress suture is placed in the anterolateral perivesical adipose tissue and tied down completely, approximately 4 cm away from the anastomosis (Fig. 2). Visible on cystogram, bladder neck intussusception results in a more narrowed bladder neck, as initially described (Fig. 3). A video description with additional technical details is available for viewing online (http://youtu.be/HrZYQsV3oRI).

2.2. Outcome measures

Urinary function during the early recovery period served as our primary outcome. We used the urinary domain of the

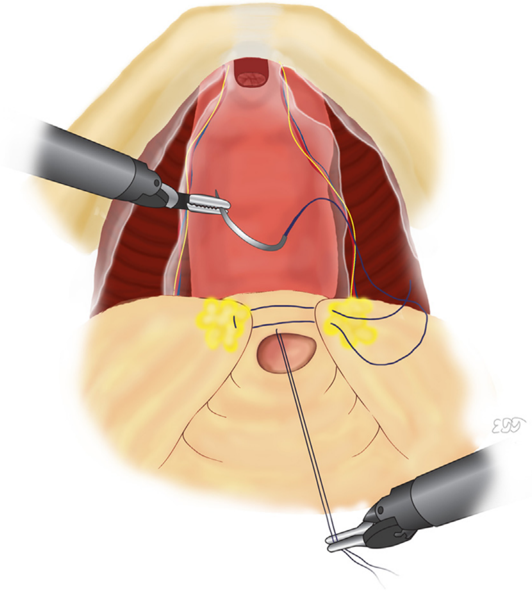


Fig. 1. Posterior bladder neck intussusception. An initial 6-o'clock anastomotic suture is placed inside-out on the urethral stump before division of the posterior apical prostatic urethra (not pictured). A second stay suture at the 6-o'clock position in the bladder neck is placed to prevent retraction of the bladder neck during intussusception. Next, a 3-0 polyglycolic horizontal mattress suture is placed posterolateral to the bladder neck in the perivesical fat and cinched down completely. (Color version of figure is available online.)

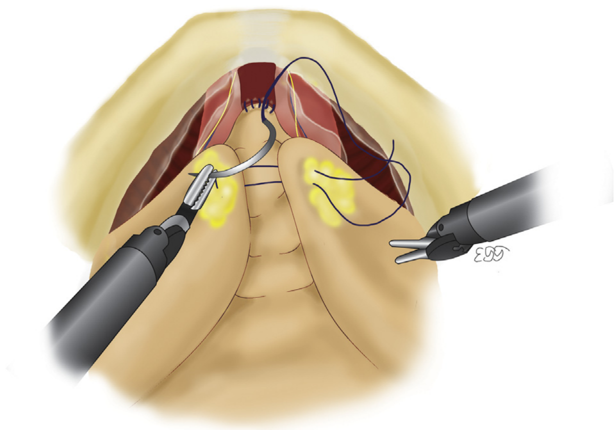


Fig. 2. Anterior bladder neck intussusception. Following the posterior bladder neck intussusception, the stay suture at the 6-o'clock position on the bladder neck is removed (not pictured). The anastomosis is then completed by placing 3 posterior interrupted 3-0 polyglycolic sutures. Two 3-0 polyglycolic sutures are then run in opposite directions and tied together at the 12-o'clock position. Another 3-0 horizontal mattress suture is placed in the anterolateral perivesical adipose tissue and tied down completely, approximately 4 cm away from the anastomosis. (Color version of figure is available online.)

Expanded Prostate Cancer Index—Short Form (EPIC-SF)—a validated questionnaire that rates bowel function, urinary control, sexual function, and health-related quality of life on a scale from 0 to 100, with higher scores representing better outcomes [14]. Because we routinely preserve the bladder neck and divide the dorsal venous complex in an athermal manner (2 modifications that also accelerate recovery), we prospectively assessed urinary function at 2 days, 2 weeks, and 2 months following catheter removal. To gauge longer-term results, we reassessed urinary function 4 to 12 months after surgery. Secondary outcomes included operative features, pathologic findings, catheter duration, and postoperative complications according to the Clavien-Dindo classification system [15].

2.3. *Power calculations and statistical analysis*

Based on the initial experience reported by Walsh and Marschke [6], we hypothesized that patients treated with bladder neck intussusception would have a more rapid recovery of urinary control. Power calculations indicated that a collective sample of 48 patients would be sufficient to identify an ordinal increase (i.e., 25–33 point increase) in urinary function, assuming a power of 80% and a significance level of 5%. Accordingly, our goal was to enroll 24 subjects each to the treatment/intussusception arm and the nonrandom control/nonintussusception arm.

We used the Student t test and the Fisher exact test to compare continuous and categorical variables, respectively. For catheter duration, we used the Wilcoxon rank sum test. Based on factors potentially associated with urinary function, we further adjusted our EPIC-SF urinary domain scores for age, race, body mass index, and D'Amico risk classification. All statistical testing was 2 sided, completed using computerized software (STATA version 13.1, College Station, TX), and performed at the 5% significance level. This study was approved by our Institutional Review Board.

3. Results

Of 48 subjects, 24 men underwent bladder neck intussusception and 24 men served as controls. Patients treated with intussusception vs. nonintussusception were similar in age (59.7 vs. 62.6 y, $P = 0.171$) and body mass index (27.3 vs. 29.5 kg/m^2, $P = 0.102$). Additionally, no difference in race, comorbidity status, previous abdominal surgery, American Society of Anesthesiologists physical status classification score, and D'Amico risk classification was observed ($P > 0.100$). Although not statistically significant, we noted a trend in higher baseline prostate-specific antigen level for those undergoing bladder neck intussusception when compared with nonintussusception (Table 1).

Operative features and outcomes are reported in Table 2. From a technical standpoint, operative time (136.4 vs. 133.1 min, $P = 0.586$), estimated blood loss (179.2 vs. 192.9 ml, $P = 0.451$), and rates of non–nerve sparing (4.2% vs. 4.2%, $P = 1.000$) remained similar between groups. We found no difference in prostate weight, positive lymph nodes, perineural invasion, or final pathologic Gleason score and stage between treatment types ($P > 0.500$). Overall, positive surgical margins occurred in 18.8% of cases—8.7% among men with pT2 disease and 28% among men with pT3 disease—with no difference between intussusception and nonintussusception (16.7% vs. 20.8%, $P = 1.000$).

Using the Clavien-Dindo classification system, 2 patients experienced a major complication (Clavien III–IV), whereas

Fig. 3. Postoperative cystogram demonstrating a narrowed and slightly kinked bladder neck following intussusception—oblique view.

Table 1
Baseline characteristics

	Intussusception, $n = 24$	Nonintussusception, $n = 24$	P value
Age, mean (SD), y	59.7 (1.5)	62.6 (1.5)	0.171
Body mass index, mean (SD), kg/m^2	27.3 (0.8)	29.5 (1.0)	0.102
Nonwhite race (%)	4 (16.7)	3 (12.5)	1.000
PSA level, mean (SD), ng/ml	10.5 (1.7)	7.0 (0.6)	0.060
Comorbidity count (%)			
0	9 (37.5)	6 (25.0)	0.534
≥1	15 (62.5)	18 (75.0)	
Previous abdominal surgery (%)	7 (29.2)	5 (20.8)	0.740
ASA physical status (%)			
1	0 (0.0)	1 (4.4)	0.188
2	19 (79.2)	21 (91.3)	
3	5 (20.8)	1 (4.4)	
D'Amico risk stratification			
Low	6 (25.0)	4 (16.7)	0.699
Moderate	14 (58.3)	17 (70.8)	
High	4 (16.7)	3 (12.5)	

ASA = American Society of Anesthesiologists; PSA = prostate-specific antigen; SD = standard deviation.

6 patients experienced a minor complication (Clavien I–II). Rates of major complications did not differ significantly between treatment groups (4.2% vs. 4.2%, $P = 1.000$). In the group of patients treated with bladder neck intussusception, 2 experienced a urine leak when compared with 1 in the nonintussusception arm. In the intussusception group, both patients faced extended travel time (>2 h driving and flying) and opted for prolonged catheterization (31 and 35 d) until a confirmatory cystogram showing resolution of extravasation could be completed. Length of stay did not differ significantly between treatment groups (1.3 vs. 1.2 d, $P = 0.730$).

Adjusted urinary function EPIC-SF scores are depicted in Fig. 4. At baseline, both the groups presented with similarly high urinary function scores (98.2 vs. 99.6, $P = 0.404$). Although urinary function appeared to be better for those receiving intussusception at the 2-day interval (49.4 vs. 43.1, $P = 0.420$), this did not reach statistical significance. At 2 weeks, men undergoing bladder neck intussusception reported significantly higher urinary function scores when compared with men in the nonintussusception group (65.4 vs. 46.6, $P = 0.019$). Based on specific responses to the EPIC-SF, more men receiving intussusception achieved no leakage, achieved total control, or did not require a pad (62.5% vs. 20.8%, $P = 0.008$) in this time interval (Table 3). EPIC-SF urinary function scores eventually converged with no difference noted at 2 months (69.5 vs. 67.9, $P = 0.929$). At a median follow-up of approximately 7 months (intussusception, 7.25 mo vs. nonintussusception, 7.5 mo), urinary function continued to be similar between the treatment group and the control group (80.5 vs. 77.0, $P = 0.665$).

4. Discussion

Despite several surgical advances, postprostatectomy incontinence remains common, morbid, and costly [1–3]. Although many men eventually improve over time, deficits in urinary control during the early recovery period impair quality of life [1,16]. In an effort to enhance recovery outcomes, several technical modifications have been described for robot-assisted laparoscopic prostatectomy. Although some of these techniques have afforded better urinary control [5,9], as many as half of the men continue to experience postprostatectomy incontinence during the first 3 months after surgery [1], suggesting an opportunity for functional improvement in men undergoing radical surgery for prostate cancer.

Table 2
Operative, pathologic, and clinical outcomes

	Intussusception, $n = 24$	Nonintussusception, $n = 24$	P value
Operative time, mean (SD), min	136.4 (3.0)	133.1 (5.1)	0.586
Estimated blood loss, mean (SD), ml	179.2 (10.7)	192.9 (14.6)	0.451
Non–nerve sparing (%)	1 (4.2)	1 (4.2)	1.000
Pathologic Gleason score (%)			
3 + 3 = 6	3 (12.5)	2 (8.3)	0.645
3 + 4 = 7 Or 4 + 3 = 7	16 (66.7)	19 (79.2)	
4 + 4 = 8 Or higher	5 (20.8)	3 (12.5)	
Pathologic category, no. (%)			
T2a	9 (37.5)	8 (33.3)	0.904
T2b	1 (4.2)	0 (0.0)	
T2c	3 (12.5)	2 (8.3)	
T3a	10 (41.7)	12 (50.0)	
T3b	1 (4.2)	2 (8.3)	
Positive margin (%)	4 (16.7)	5 (20.8)	1.000
T2a–c	0 (0.0)	2 (15.4)	0.486
T3a–b	4 (28.6)	3 (27.3)	1.000
Prostate size, mean (SD), g	45.9 (5.4)	48.2 (3.0)	0.717
Perineural invasion (%)	6 (25.0)	8 (33.3)	0.752
Positive lymph nodes (%)	1 (4.2)	1 (4.2)	1.000
Length of stay, mean (SD), d	1.3 (0.2)	1.2 (0.2)	0.730
Catheter duration, median, d	8	8	0.125
Postoperative complication	5 (20.8)	3 (12.5)	0.701
Clavien I–II	4 (16.7)	2 (8.3)	0.666
Clavien III–IV	1 (4.2)	1 (4.2)	1.000

SD = standard deviation.

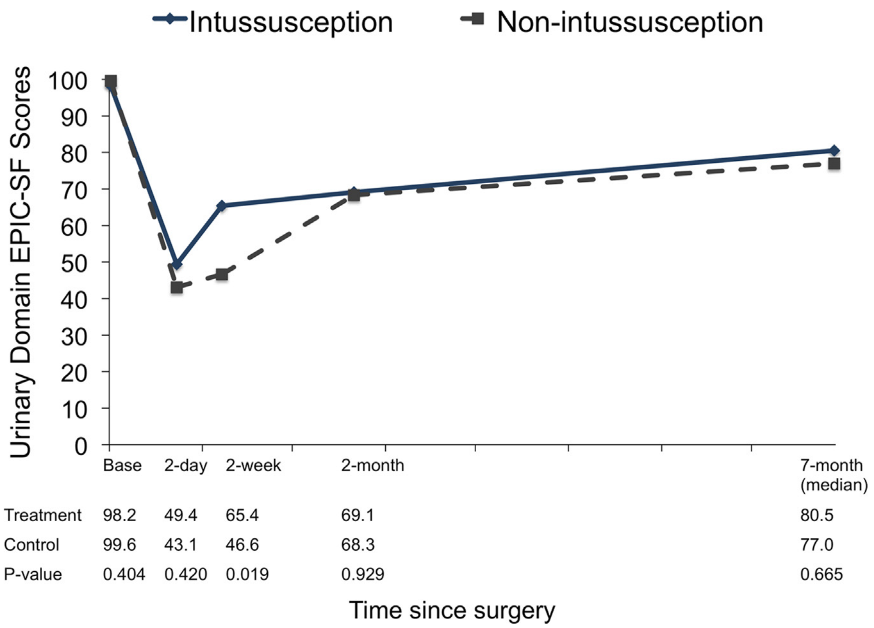


Fig. 4. Baseline, 2-day, 2-week, 2-month, and 7-month (median) EPIC-SF urinary domain scores among men receiving intussusception vs. nonintussusception with robot-assisted laparoscopic prostatectomy. Intussusception with a median follow-up of 7.25 months (interquartile range: 5.5–8.75 mo) vs. nonintussusception with a median follow-up of 7.5 months (interquartile range: 5.0–9.5 mo), $P = 0.766$ based on Wilcoxon rank sum test. Scores are adjusted for age, body mass index, race, and D'Amico risk classification. Significant difference noted at 2 weeks based on an alpha level of 0.05. Unadjusted scores revealed similar findings. (Color version of figure is available online.)

In 2002, after reaching a plateau in functional outcomes [17–19], Walsh and Marschke [6] described bladder neck intussusception as a mechanical means to improve post-prostatectomy incontinence. By using buttressing sutures anterior and posterior to the bladder neck, he increased 3-month continence rates—defined as zero or dry pad—from 54% to 82% without any increase in bladder neck contractures or related complications. However, subsequent assessments have been mixed, and none have assessed this technique in the laparoscopic or robotic setting [7,8].

Table 3
Proportion of patients with no leakage, total control, or zero pads according to the urinary domain of the EPIC-SF

Time interval	Urinary function	Intussusception, $n = 24$	Nonintussusception, $n = 24$	P value
2 Days	No leakage	2 (8.3)	3 (12.5)	1.000
	Total control	3 (12.5)	3 (12.5)	1.000
	No pad use	6 (25.0)	4 (16.7)	0.724
	Any of above	8 (33.3)	6 (25.0)	0.752
2 Weeks	No leakage	4 (16.7)	2 (8.3)	0.666
	Total control	7 (29.2)	3 (12.5)	0.286
	No pad use	10 (41.7)	4 (16.7)	0.111
	Any of above	15 (62.5)	5 (20.8)	0.008
2 Months	No leakage	10 (41.7)	10 (41.7)	1.000
	Total control	12 (50.0)	11 (45.8)	1.000
	No pad use	12 (50.0)	13 (54.2)	1.000
	Any of above	13 (54.2)	13 (54.2)	1.000
7 Months[a] (median)	No leakage	11 (50.0)[b]	14 (58.3)	0.768
	Total control	12 (54.6)[b]	15 (62.5)	0.765
	No pad use	16 (72.7)[b]	13 (54.2)	0.233
	Any of above	17 (77.3)[b]	17 (70.8)	0.742

[a] Intussusception with median follow-up of 7.25 months (interquartile range: 5.5–8.75 mo) vs. nonintussusception with median follow-up of 7.5 months (interquartile range: 5.0–9.5 mo); $P = 0.766$ based on Wilcoxon rank sum test.

[b] Based on $n = 22$ because 2 patients in the intussusception arm were lost to follow-up.

Potential challenges to perform intussusception during laparoscopic surgery are the cephalad camera angle vantage point and running vs. interrupted anastomotic techniques during minimally invasive vs. open surgery. These nuances require subtle modification when performing intussusception during robot-assisted laparoscopic prostatectomy.

Our study demonstrates the feasibility and potential effectiveness of bladder neck intussusception during robot-assisted laparoscopic prostatectomy. Among men with similar features, intussusception may be performed without substantial prolongation of operating time or compromise in clinicopathologic outcomes. Furthermore, patients who underwent intussusception achieved quicker return of urinary function when compared with patients who did not undergo intussusception, with higher urinary function scores at 2 days and statistically significant increases at 2 weeks. The 19-point urinary function score advantage for intussusception at 2 weeks exceeds the 6- to 9-point threshold for clinical significance described previously [20]. Approximately, two-thirds of patients receiving intussusception reported no leakage, complete control, or zero pad use within weeks of surgery, reducing the period of urinary impairment following prostatectomy.

Although these data support the effectiveness of bladder neck intussusception, the therapeutic window appears more compact when compared with that of previous studies [6,7]. In these reports, authors noted higher rates of continence at 3 months, whereas our findings indicate equivalency by 2 months. One potential explanation could be our use of bladder neck preservation—a technique not used during these initial series. Although the follow-up intervals differ slightly, the 2-month urinary outcomes reported in this trial compare favorably to outcomes reported 1 to 3 months postoperatively following bladder neck preservation [5]. Additionally, the effect size at 2 weeks appears to be larger than that observed with bladder neck preservation and on par with selective suturing and athermal division of the dorsal venous complex [5,9]. Given these findings and those reported with open surgery, bladder neck intussusception improves urinary control and may serve as a potential augment or alternative to other well-popularized modifications depending on the surgical circumstances of the procedure.

Although promising, there may be additional opportunities to prolong the effect and improve the safety of bladder neck intussusception. In the initial description, Walsh and Marschke [6] used polyglyconate for the buttressing suture, which spurs less inflammation and better retains tensile strength when compared with the polyglycolic suture [21]. More recently, barbed polyglyconate sutures have been used for the vesicourethral anastomosis in robot-assisted laparoscopic prostatectomy. Although its comparative and cost-effectiveness remains less clear for the anastomosis, polyglyconate and its associated features may extend the benefit of intussusceptions [12,22]. Additionally, we noted 2 urine leaks in the intussusception arm compared with 1 in the control group. Although not significantly different, we have noticed increased tension on the vesicourethral anastomosis with intussusception owing to reduced bladder neck length. To this end, combining bladder neck intussusception with posterior or anterior reconstruction may offer additional anastomotic support, thereby reducing the risk for subsequent urine leaks [1]. Although early results are promising, additional adjustments may add to the technique's safety and effectiveness, as it is assessed in subsequent comparative trials.

Finally, these findings also highlight the potential role for new training methods in urology. With emerging evidence demonstrating a link between peer rating of technical skill and surgical complications, there is growing interest in defining the role for coaching among both novice trainees and experienced surgeons [23,24]. To adapt bladder neck intussusception to robot-assisted prostatectomy, we used video recording, postoperative debriefing, and coaching by a more experienced surgeon. Because of geographic restrictions, we implemented these training tools through social networking interfaces, which have been shown to enhance skill acquisition [24,25]. For instance, proper intussusception technique involves more proximal and robust placement of the horizontal mattress sutures in the perivesical adipose tissue while avoiding bladder muscle—a subtle point that may have been overlooked without critical feedback made available through social media. By bundling these techniques, we rapidly and effectively operationalized bladder neck intussusception to the robotic platform, leading to measurable patient benefit. As we move toward more stringent training and credentialing requirements [26], these training tools may be the most efficient way to ensure proficient adoption of new surgical techniques.

These findings should be considered in the context of the study design. Our study is not randomized and therefore vulnerable to potential selection bias. Although a randomized control would be preferable, we found that, in this instance, issues related to clinical equipoise and patient preference limited our ability to implement such a trial. To address some methodological concerns, we collected data prospectively and used a nonrandom control with both treatment and control groups appearing similar. Slight, nonsignificant differences in age and body mass index may still lead to bias. However, previous studies suggest that the effect of age on postprostatectomy incontinence stems from differences in baseline function, while obesity impairs urinary function over the long term [27,28]. In this study, we observed no difference in baseline function and focused on short-term functional outcomes. Furthermore, we adjusted for several established risk factors for postprostatectomy incontinence. On a separate note, these findings are based on a single surgeon and may have limited generalizability, as outcomes may also rely on surgeon experience, teaching environment, patient population, and concurrent surgical maneuvers (e.g., bladder neck preservation and athermal division of the dorsal venous complex). Larger, multi-institutional assessments may be necessary to gain additional, more generalizable information on safety and effectiveness.

5. Conclusion

Among men undergoing robot-assisted laparoscopic prostatectomy, the addition of bladder neck intussusception enhances early recovery of urinary function while yielding similar clinicopathologic outcomes. With video-based coaching, this technique may be quickly adopted and may help reduce the burden of urinary impairment for men seeking surgical treatment for localized prostate cancer.

Appendix A. Supplementary Material

Supplementary data associated with this article can be found in the online version at 10.1016/j.urolonc.2015.01.012.

References

[1] Ficarra V, Novara G, Rosen RC, et al. Systematic review and meta-analysis of studies reporting urinary continence recovery after robot-assisted radical prostatectomy. Eur Urol 2012;62:405–17.

[2] Schroeck FR, Krupski TL, Sun L, et al. Satisfaction and regret after open retropubic or robot-assisted laparoscopic radical prostatectomy. Eur Urol 2008;54:785–93.

[3] Wagner TH, Hu TW. Economic costs of urinary incontinence in 1995. Urology 1998;51:355–61.

[4] Nyarangi-Dix JN, Radtke JP, Hadaschik B, Pahernik S, Hohenfellner M. Impact of complete bladder neck preservation on urinary continence, quality of life and surgical margins after radical prostatectomy: a randomized, controlled, single blind trial. J Urol 2013; 189:891–8.

[5] Freire MP, Weinberg AC, Lei Y, et al. Anatomic bladder neck preservation during robotic-assisted laparoscopic radical prostatectomy: description of technique and outcomes. Eur Urol 2009;56:972–80.

[6] Walsh PC, Marschke PL. Intussusception of the reconstructed bladder neck leads to earlier continence after radical prostatectomy. Urology 2002;59:934–8.

[7] Wille S, Varga Z, von Knobloch R, Hofmann R. Intussusception of bladder neck improves early continence after radical prostatectomy: results of a prospective trial. Urology 2005;65:524–7.

[8] Sakai I, Harada K, Hara I, Eto H, Miyake H. Intussusception of the bladder neck does not promote early restoration to urinary continence after non-nerve-sparing radical retropubic prostatectomy. Int J Urol 2005;12:275–9.

[9] Lei Y, Alemozaffar M, Williams SB, et al. Athermal division and selective suture ligation of the dorsal vein complex during robot-assisted laparoscopic radical prostatectomy: description of technique and outcomes. Eur Urol 2011;59:235–43.

[10] Schaeffer EM, Partin AW, Lepor H, Walsh PC. Campbell-Walsh urology: chapter 102—radical retropubic and perineal prostatectomy, 10th ed. Saunders: 2011.

[11] Kowalczyk KJ, Huang AC, Hevelone ND, et al. Stepwise approach for nerve sparing without countertraction during robot-assisted radical prostatectomy: technique and outcomes. Eur Urol 2011;60:536–47.

[12] Williams SB, Alemozaffar M, Lei Y, et al. Randomized controlled trial of barbed polyglyconate versus polyglactin suture for robot-assisted laparoscopic prostatectomy anastomosis: technique and outcomes. Eur Urol 2010;58:875–81.

[13] Berry AM, Korkes F, Ferreira M, Hu JC. Robotic urethrovesical anastomosis: combining running and interrupted sutures. J Endourol 2008;22:2127–9.

[14] Wei JT, Dunn RL, Litwin MS, Sandler HM, Sanda MG. Development and validation of the expanded prostate cancer index composite (EPIC) for comprehensive assessment of health-related quality of life in men with prostate cancer. Urology 2000;56:899–905.

[15] Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 2004;240:205–13.

[16] Resnick MJ, Koyama T, Fan KH, et al. Long-term functional outcomes after treatment for localized prostate cancer. N Engl J Med 2013;368:436–45.

[17] Walsh PC. Anatomic radical prostatectomy: evolution of the surgical technique. J Urol 1998;160:2418–24.

[18] Walsh PC. Patient-reported impotence and incontinence after nerve-sparing radical prostatectomy. J Urol 1998;159:308–9.

[19] Walsh PC, Lepor H, Eggleston JC. Radical prostatectomy with preservation of sexual function: anatomical and pathological considerations. Prostate 1983;4:473–85.

[20] Skolarus TA, Dunn RL, Sanda MG, et al. Minimally important difference for the expanded prostate cancer index composite short form. Urology 2015;85:101–6.

[21] Bourne RB, Bitar H, Andreae PR, Martin LM, Finlay JB, Marquis F. In-vivo comparison of four absorbable sutures: Vicryl, Dexon Plus, Maxon and PDS. Can J Surg 1988;31:43–5.

[22] Sammon J, Kim TK, Trinh QD, et al. Anastomosis during robot-assisted radical prostatectomy: randomized controlled trial comparing barbed and standard monofilament suture. Urology 2011;78:572–9.

[23] Birkmeyer JD, Finks JF, O'Reilly A, et al. Surgical skill and complication rates after bariatric surgery. N Engl J Med 2013;369: 1434–42.

[24] Hu YY, Peyre SE, Arriaga AF, et al. Postgame analysis: using video-based coaching for continuous professional development. J Am Coll Surg 2012;214:115–24.

[25] Carter SC, Chiang A, Shah G, et al. Video-based peer feedback through social networking for robotic surgery simulation: a multicenter randomized controlled trial. Ann Surg 2015;261:870–5.

[26] Zorn KC, Gautam G, Shalhav AL, et al. Training, credentialing, proctoring and medicolegal risks of robotic urological surgery: recommendations of the society of urologic robotic surgeons. J Urol 2009;182:1126–32.

[27] Wiltz AL, Shikanov S, Eggener SE, et al. Robotic radical prostatectomy in overweight and obese patients: oncological and validated-functional outcomes. Urology 2009;73:316–22.

[28] Brajtbord JS, Punnen S, Cowan JE, Welty CJ, Carroll PR. Age and baseline quality of life at radical prostatectomy—who has the most to lose? J Urol 2014;192:396–401.

EUROPEAN UROLOGY 76 (2019) 814–822

available at www.sciencedirect.com
journal homepage: www.europeanurology.com

European Association of Urology

Surgery in Motion

Posterior, Anterior, and Periurethral Surgical Reconstruction of Urinary Continence Mechanisms in Robot-assisted Radical Prostatectomy: A Description and Video Compilation of Commonly Performed Surgical Techniques

André N. Vis[a,*], *Henk G. van der Poel*[b], *Annebeth E.C. Ruiter*[a], *Jim C. Hu*[c], *Ashutosh K. Tewari*[d], *Bernardo Rocco*[e], *Vipul R. Patel*[f], *Sanjay Razdan*[g], *Jakko A. Nieuwenhuijzen*[a]

[a] *VU University Medical Center, Amsterdam, The Netherlands;* [b] *Antoni van Leeuwenhoek Ziekenhuis, Amsterdam, The Netherlands;* [c] *New York Presbyterian/Weill Cornell, New York, NY, USA;* [d] *Icahn School of Medicine of Mount Sinai, New York, NY, USA;* [e] *University of Modena and Reggio Emilia, Modena, Italy;* [f] *Global Robotics Institute, Florida Hospital Celebration Health, Orlando, FL, USA;* [g] *International Robotic Prostatectomy Institute, Miami, FL, USA*

Article info

Article history:
Accepted November 15, 2018

Associate Editor:
Alexandre Mottrie

Keywords:
Robot-assisted radical prostatectomy
Prostate cancer
Incontinence
Reconstruction
Posterior
Anterior
Suspension

Please visit www.europeanurology.com and www.urosource.com to view the accompanying video.

Abstract

Background: Robot-assisted radical prostatectomy (RARP) is hampered by side effects that may have a serious impact on quality of life, particularly stress urinary incontinence. Continence rates may be improved by surgical reconstruction of the pelvic floor.
Objective: Video illustrations of different surgical techniques may be particularly worthwhile for practicing urologists in understanding the pelvic-floor anatomy and in the training of residents and fellows in urology.
Design, setting, and participants: We describe and video-illustrate commonly performed pelvic reconstructive techniques in RARP, as performed by experts in the field.
Surgical procedure: Surgical techniques have been described, such as posterior musculofascial reconstruction, anterior reconstruction and periurethral suspension, preservation of membranous urethral lengthening, bladder-neck reconstruction, and combinations.
Measurements: An overview of continence rates of the different techniques is given.
Results and limitations: All reconstructive surgical techniques result in similar short-term continence rates and good-to-excellent outcomes 1 yr after surgery. There are only a few randomized clinical trials comparing a reconstructive technique with "no reconstruction" or a different reconstructive technique, and outcomes are conflicting.
Conclusions: Although many of the procedures report a benefit with respect to early continence, benefits seem to diminish with longer follow-up. Whether any of the reconstructive techniques is superior to another is a matter of study.
Patient summary: Early continence rates might be improved by surgical reconstruction of the pelvic floor.

---

* Corresponding author. Department of Urology, Amsterdam UMC, Vrije Universiteit Amsterdam, room 4F27, De Boelelaan 1117, Postbus 7057, Amsterdam 1081HV, The Netherlands.
Tel. +31 204440261; Fax. +31 204446031.
E-mail address: a.vis@vumc.nl (A.N. Vis).

https://doi.org/10.1016/j.eururo.2018.11.035
0302-2838/© 2018 European Association of Urology. Published by Elsevier B.V. All rights reserved.

1. Introduction

Robot-assisted radical prostatectomy (RARP) is the main curative surgical approach in localized prostate cancer. The surgical procedure is, however, known to be hampered by side effects that may have a serious impact on quality of life, particularly stress urinary incontinence (SUI). The incidence of bothersome SUI has been reported in 4–31% of patients 1 yr after RARP [1].

RARP may result in severe infravesical changes. It shortens the urethral length, reduces bladder-outlet resistance, may hamper bladder-neck sphincteric function, and changes the structure and function of the urinary sphincteric complex. This urinary sphincteric complex contains periurethral smooth muscles, an omega-shaped loop of striated muscles around the membranous urethra (ie, the rhabdosphincter), and further supporting connective tissues [2]. This combined anatomical functionality is aimed to withstand increased abdominal pressure, thereby facilitating urinary continence. Multiple efforts have been made to improve continence rates by surgical reconstruction of the pelvic floor. A wide range of techniques has been described, such as posterior musculofascial reconstruction, anterior reconstruction and periurethral suspension, anatomical (total) pelvic reconstruction, preservation of membranous urethral lengthening (MUL), bladder-neck reconstruction, and combinations. The efficacy of these surgical techniques has been reported in different cohort, nonrandomized and randomized studies and a meta-analysis of posterior musculofascial reconstruction [3].

We describe and video-illustrate commonly performed pelvic reconstruction techniques in RARP, as performed by experts in the field. We also outline and compare the early and late continence rates as reported. The video illustrations may be particularly worthwhile for practicing urologists in understanding the pelvic-floor anatomy and in the training of residents and fellows in urology.

2. Patients and methods

2.1. *Selection of surgical reconstructive procedures*

The underlined pelvic-floor reconstruction techniques in RARP are selected for efficacy and demonstrated in detailed video presentations. The selection is based on the presence of a detailed anatomical description of the surgical technique in the peer-reviewed literature and/or the availability of scrutinized video illustrations (www.europeanurology.com, www.surgeryinmotion-school.org, and www.urosource.com). Special attention is given to the robot-assisted approach, as this approach is used in the majority of hospitals today and because a robotic-training program is endorsed by the European Robotic Urological Society and the European Urology Scholarship Programme.

2.2. *Description of surgical techniques*

2.2.1. *Posterior reconstruction ("Rocco" stitch)*

This procedure was first described by Rocco et al. [4] in an open approach, and was further investigated in detail in conventional laparoscopic series and in a review of literature on RARP [5,6]. The technique entails realignment of the supportive structures that lie dorsal to the bladder, prostate, and urethra. In anatomical literature, there is no consensus on the nomenclature, resulting in several terms such as Denonvilliers' fascia, the fascia of the vesicoprostatic muscle, the rhabdosphincter, or the median dorsal fibrous raphe. 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, thereby stabilizing the sphincteric complex and preserving the urethra in its anatomic and functional position in the pelvic floor. For this procedure, it is important that the urethra itself is not involved in the reconstructive sutures. Moreover, the reconstructive suture should not run too laterally since it may damage the neurovascular bundles running lateral to the urethra. The vesicourethral anastomosis might be easier to perform after posterior reconstruction and hemostasis is improved.

2.2.2. *Periurethral suspension stitch ("Patel" stitch)*

The periurethral retropubic suspension stitch has been described by Walsh [7] in an open radical retropubic prostatectomy series, and Patel et al. [8] were the first to describe this suspension technique in RARP. The technique is based on placement of a puboperiurethral suspension stitch after ligation of the dorsal venous complex (DVC). The suture is placed between the urethra and the DVC, passed through the periosteum of the pubic bone, and back through to the DVC in multiple figure-eight loops.

2.2.3. *Anterior suspension combined with posterior reconstruction*

Hurtes et al. [9] combined two previous techniques: first anterior urethral suspension, followed by posterior reconstruction. Anterior reconstruction can also be performed after making the vesicourethral anastomosis, as described by one of the largest monocenter series [10]. After preservation of the anterior supporting structures such as the puboprostatic ligaments and the arcus tendineus, and after performing a posterior reconstruction, the arcus tendineus and the puboprostatic ligaments are reattached to the anterolateral distal bladder. Different surgical reconstructive techniques have been adopted, as shown in the accompanying video.

2.2.4. *Advanced reconstruction of vesicourethral support*

Student et al. [11] investigated the technique of a semicircular support for the urethra and vesicourethral anastomosis on continence rates after RARP. The principle behind the advanced reconstruction of vesicourethral support (ARVUS) consists of creating a semicircle of surrounding musculature around the vesicourethral anastomosis without injuring the neurovascular bundles. The medial aspects of the levator ani muscle are adjusted to Denonvilliers' fascia, and the suture is then continued to fix the median dorsal raphe to the detrusor bladder neck through the retrotrigonal layer. This technique is aimed at creating a strong support for the vesicourethral anastomosis. In ARVUS, it is assumed that multiple reconstructive principles restore or rebuild the presurgical anatomy.

2.2.5. *Total anatomical reconstruction*

Porpiglia et al. [12] described the functional outcomes of total anatomical reconstruction (TAR) during RARP. TAR consists of posterior reconstruction in three layers and anterior reconstruction in two layers. The first posterior layer is the realignment of Denonvilliers' fascia to the median dorsal raphe. The second layer involves the retrotrigonal fascia and median raphe, whereas the third layer involves the bladder neck and the posterior aspect of the rhabdosphincter. After this posterior reconstruction, vesicourethral anastomosis is performed and is followed by anterior reconstruction. The first anterior layer is aimed at restoring the original anatomy by suturing the muscular fibers of the bladder neck to the periurethral tissue located between the DVC and the urethra. The second anterior layer consists of the visceral and parietal layers of the endopelvic fascia in order to recreate the "pubovesical" ligaments.

Table 1 – Short description of the anatomical structures that are sutured, realigned, approximated, or reconstructed in each of the surgical reconstructive procedures after RARP—the reported suture for anatomical reconstruction

Surgical procedure	Description of surgical technique and supposed mechanism by which continence is achieved	Suture as reported[a]
Posterior reconstruction of the rhabdomyosphincter (“Rocco” stitch) [6,24]	Realignment of the tissues dorsal to the bladder and the urethra providing a tension-free vesicourethral anastomosis and recreating posterior support for the urethra and urethrosphincteric complex	Two 3-0 poliglecaprone RB-1 needle or Monocryl 2-0 anchoring suture
Periurethral suspension stitch (“Patel stitch”) [8]	Suspension of the tissues ventral to the urethra on the fascia of the pubic bone providing anatomical support and stabilization of the urethra	12-in monofilament Polyglytone suture on a CT-1 needle
Anterior suspension and posterior reconstruction technique [9,10]	Combination of anterior and posterior reconstruction (see above)	Polyglactin absorbable suture or two 3-0 poliglecaprone monofilament sutures on an RB-1 needle
Advanced reconstruction of vesicourethral support [11]	Restoration of anatomical relations between levator muscle, Denonvilliers’ fascia, median dorsal raphe, and the rhabdosphincter	Barbed V-lock 2/0 monofilament
Total anatomical reconstruction [12]	Combination of a three-layer posterior reconstruction and a two-layer anterior reconstruction to support the vesicourethral anastomosis and periurethral structures	Barbed 3/0 monofilament
Modified maximal urethral length preservation technique [13]	Increasing the length of the functional sphincteric mechanism by adding intraprostatic urethral length	NR
Bladder-neck preservation [14]	Preserving the bladder neck with its preprostatic “internal” sphincter	NR

NR = not reported; RARP = robot-assisted radical prostatectomy.

[a] As of today, many reconstructive techniques are performed using a barbed wire stitch.

2.2.6. *Modified MUL technique*

One of the principles for achieving continence after radical prostatectomy is to preserve a functional urinary sphincter mechanism by achieving MUL. An increased urethral length, which includes a greater amount of smooth muscles and the rhabdosphincter, increases the length of the urethra pressure profile [2]. Hamada et al. [13] described the MUL-preservation technique. After dissecting the DVC, the prostatic apex and the rhabdosphincter are seen. From the prostatic-rhabdosphincter junction toward the membranous urethra, the striated and smooth muscle fibers are smoothly divided. Together with the release of fibrous connections of the prostate at the apex, an additional length of the intra-abdominal urethra is obtained.

2.2.7. *Anatomic bladder-neck preservation*

Freire et al. [14] described their technique of bladder-neck–sparing surgery in RARP. The anterior bladder is tented by traction of the anterocephalad part of the detrusor muscle to form a ridge that ends distally at the detrusor apron. A funneled bladder neck is created by finding a cleavage plane using a combination of sharp and blunt dissection to tease bladder muscle fibers away from the prostate. One of the key principles is minimal use of monopolar cautery, which chars the tissue and obscures the anatomic plane between the prostate and the bladder. Instead, there is greater reliance on bipolar and sharp dissection. After dissecting anteriorly and circumferentially, the catheter balloon is deflated and the linear anterior fibers of the bladder neck are incised as distally as possible.

3. Results

3.1. *Description of anatomical principles*

Table 1 gives a short description of the anatomical structures that are realigned, approximated, suspended, or reconstructed. Fig. 1 shows the anatomical landmarks within the pelvic floor prior to reconstruction after RARP and after the vesicourethral anastomosis. Figs. 2–7 show the surgical reconstructive techniques graphically.

3.2. *Outcome of surgical reconstructive techniques*

Table 2 gives an overview of the continence rates in time after surgery as reported by different study groups of different reconstructive procedures.

3.2.1. *Evaluation of RCTs*

Joshi et al. [6] randomized 109 patients to either posterior reconstruction or no reconstruction, and found no significant differences for either involuntary urine loss or pad use at both 3 and 6 mo postoperatively. Sutherland et al. [15] did not find a difference in early continence at 3 mo in 94 men randomized to posterior reconstruction and standard technique. These outcomes were different from those of Ogawa et al. [16] who randomly compared three-layer posterior reconstruction with standard reconstruction (Table 2).

Menon et al. [17] evaluated 57 patients who underwent a no-reconstruction technique with a technique in which anastomosis was preceded by posterior reconstruction and followed by anterior reconstruction ($n = 59$). Eventually, no improvement in early continence rate was found. No difference in continence outcome was reported on longer follow-up [18]. In an RCT comparing no reconstruction ($n = 33$) with anterior and posterior reconstructions ($n = 39$), Hurtes et al. [9] demonstrated significantly higher continence rates in the reconstruction group at 1 and 3 mo, although without a difference for the very early (15 d) and late (6 mo) time intervals. The group of Aalst, Belgium, performed similar randomization between no reconstruction ($n = 26$) and a combined anterior and posterior reconstructive technique ($n = 24$) [19]. At catheter removal and at 7 wk, more patients in the reconstruction group were continent compared with men in the no-reconstruction group.

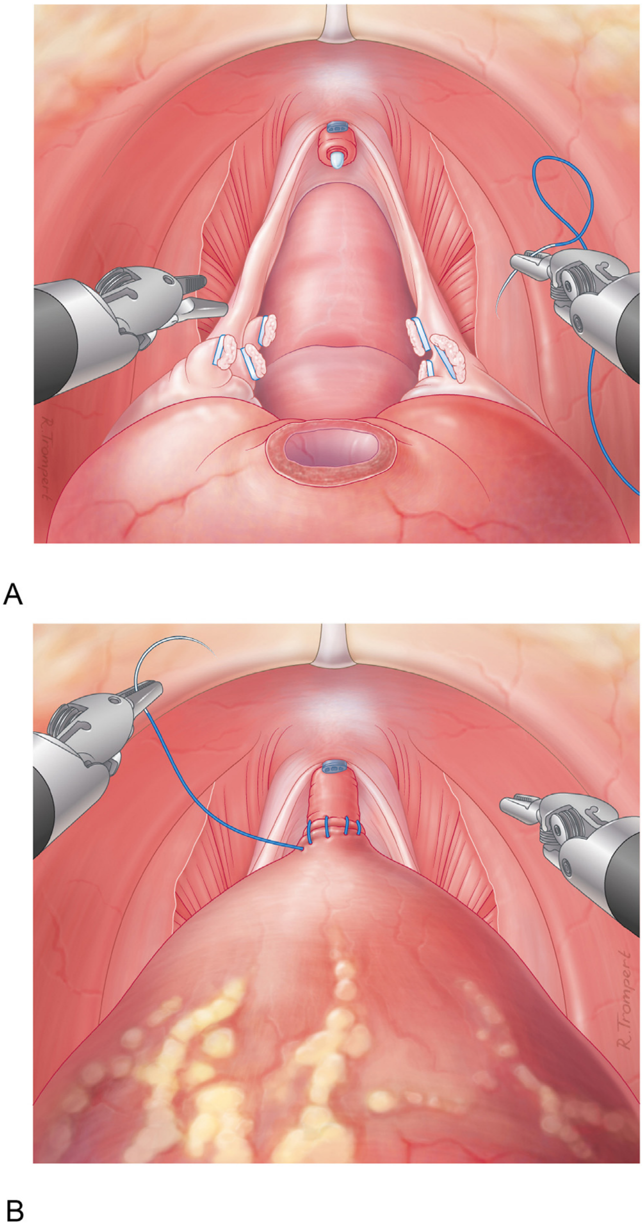


Fig. 1 – (A) Pelvic-floor anatomy after radical prostatectomy. The supporting structures in the pelvic floor, such as the periurethral smooth muscles, periurethral connective tissues, median dorsal fibrous raphe, Denonvilliers' fascia (or vesicoprostatic muscle), and levator ani muscles, are shown. Supporting structures also include the fascia endopelvica with puboprostatic ligaments and the arcus tendineus. The neurovascular bundle is shown dorsolateral to the resected prostate. (B) Pelvic-floor anatomy after radical prostatectomy and after suturing the vesicourethral anastomosis.

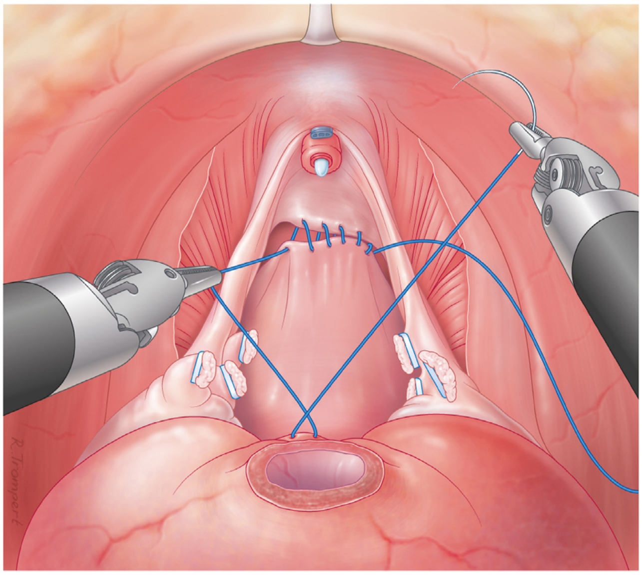


Fig. 2 – Posterior reconstruction ("Rocco" stitch). Realignment of the supportive structures that lie dorsal to the bladder and the urethra, providing a tension-free vesicourethral anastomosis and recreating a posterior support for the urethra and the urethrosphincteric complex.

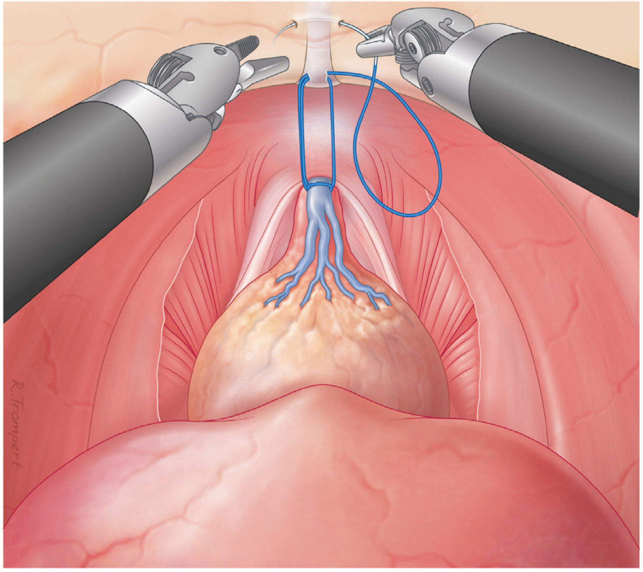


Fig. 3 – Periurethral suspension stitch ("Patel" stitch). The urethra is suspended by anchoring the supportive tissues ventral of the urethra to the periosteum of the pubic bone and back through the dorsal vascular complex for ligation. By this, an anatomical support is created and the urethra stabilized.

Recently, Student et al. [11] randomized 66 patients to either posterior or ARVUS technique. Patients in the ARVUS group achieved better early (2–8 wk) and late (1 yr) continence rates compared with those in the control group.

4. Discussion

One of the major drawbacks of RARP is urinary incontinence. Although most men experience SUI in the early postoperative period, urge urinary incontinence is also common. SUI after radical prostatectomy is generally defined as any involuntary loss of urine or pad use, but definitions and means of recording vary widely between study groups. SUI occurs in 4–31% of cases 1 yr after surgery and has a recognized negative impact on quality of life [1]. A number of modifiable and nonmodifiable factors are known to influence SUI rates, such as age, body mass index,

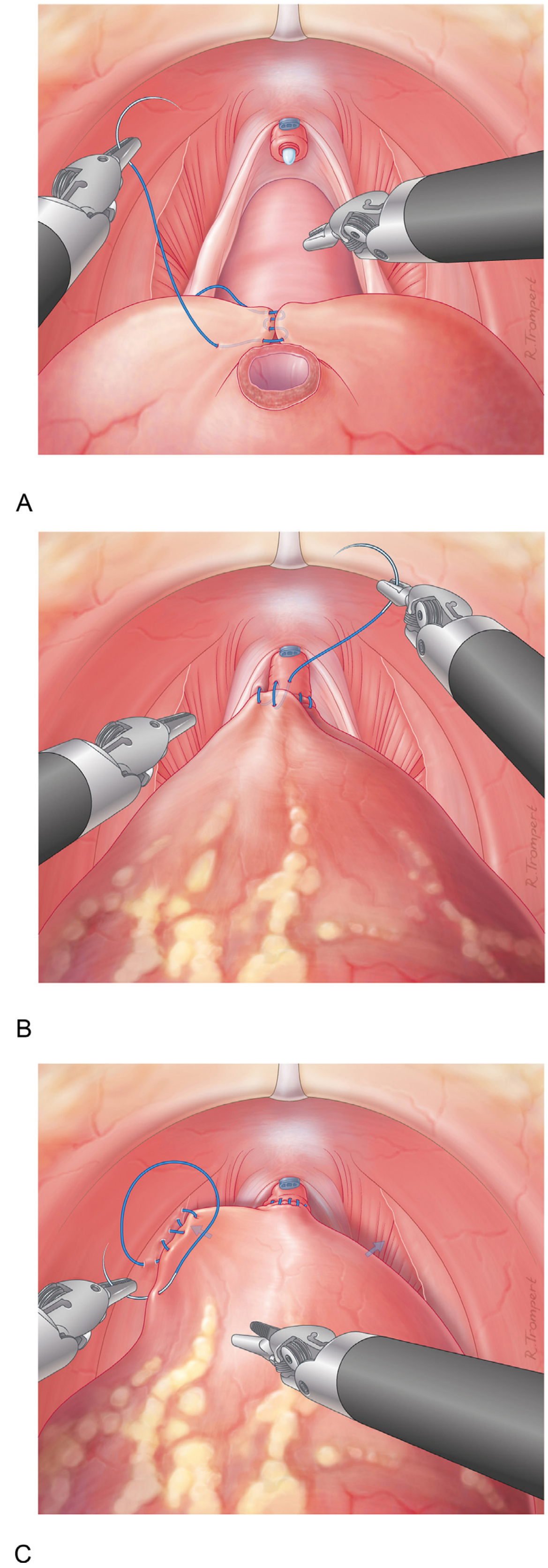


Fig. 4 – Anterior suspension combined with posterior reconstruction. Different surgical techniques may be combined to mimic the anatomical situation before radical prostatectomy. (A) A posterior reconstruction is performed by approximating the tissues dorsal from the bladder neck, (B) followed by anterior reconstruction, suturing the muscular fibers of the bladder neck to the periurethral tissues between the DVC and the anastomosed urethra, and (C) realigning the bladder to the pelvic sidewall to recreate the endopelvic fascia. DVC = dorsal vascular complex.

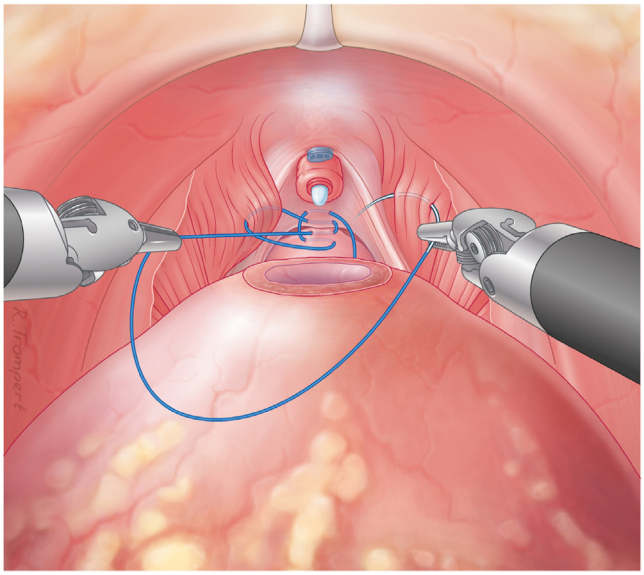


Fig. 5 – Advanced reconstruction of vesicourethral support. A semicircular support of the urethra is recreated by adjusting the medial aspects of the levator muscle to Denonvilliers' fascia and then continued to attach the median dorsal fibrous raphe to the detrusor bladder neck.

preoperative voiding problems, prostate volume, comorbidities, surgical experience, and surgical technique. The effect of pelvic-floor muscle exercise before and after surgery on postoperative SUI rate is limited [20].

As of yet, it is not completely understood which anatomical and functional mechanisms will lead to SUI after RARP. It is postulated that alterations in the muscular and supportive structures of the bladder neck, urethra, and muscular sphincter complex may result in an inability to withstand intra-abdominal pressures. The additive role of the periurethral prostatic tissue, length of the prostatic urethra, and the internal intrinsic sphincter is unclear. If increased intra-abdominal pressures are not guided properly along the structures within the pelvic floor, SUI may occur. Surgical reconstruction of pelvic-floor structures therefore aims to enhance pelvic-floor support, resembling the presurgical state. It is yet unknown whether reconstruction of the peritoneum and/or arcus tendineus on the pubic bone adds any further to the stabilization of pelvic-floor structures. Other hypotheses for SUI after RARP have been put forward. Michl et al. [21] hypothesized that meticulous apical dissection during nerve-sparing surgery additionally spares autonomic nerves that run along the prostatic apex and innervate the rhabdosphincter. Preservation of these pudendal nerve fibers might enhance continence independently of anatomical changes in the supportive structures after RARP. Similar findings were

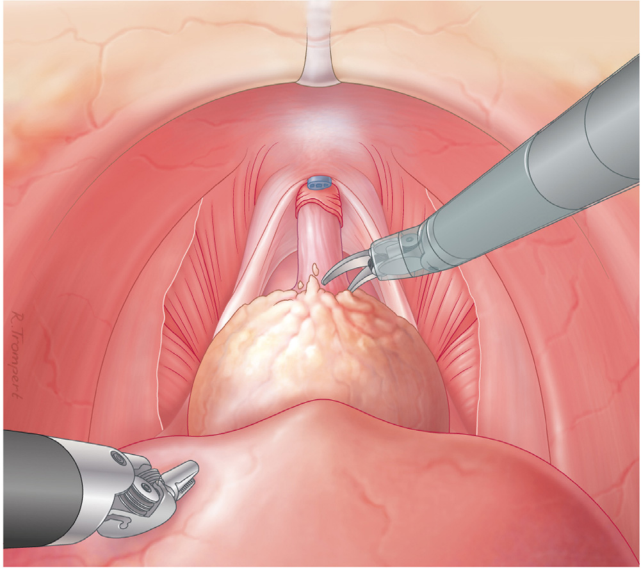


Fig. 6 – Modified maximal urethral length technique. An increased length of the membranous urethra is obtained by releasing the fibrous and muscular connective tissues of the prostate at the apex.

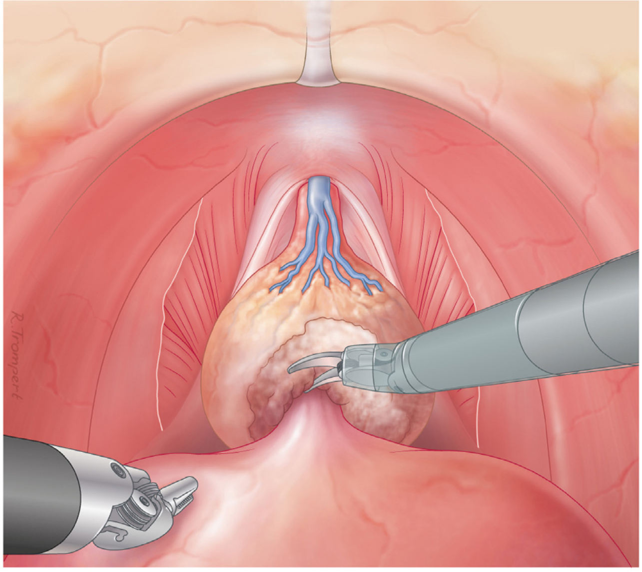


Fig. 7 – Bladder-neck–sparing surgery. Bladder-neck preservation is maintained by a combination of sharp and blunt dissection to tease bladder muscle fibers away from the prostate. The bladder neck is created as distally as possible.

reported by Lei et al. [22] who showed that selective suture ligation of the DVC resulted in more meticulous apical dissection, thereby sparing the rhabdosphincter and autonomic nerve fibers that run into the sphincteric muscle complex.

Pelvic-floor reconstruction was first reported by Rocco et al. [4] as posterior reconstruction during open radical prostatectomy and later in a series of cohort studies of patients undergoing RARP [23–26]. In a meta-analysis, it was shown that posterior musculofascial reconstruction allows for a better approximation of the vesicourethral anastomosis and statistically significant better continence rates 90 d postoperatively compared with the no-reconstruction technique [3]. The result of this meta-analysis is suggestive that these reconstructions improve early continence rates. Nevertheless, the only two true RCTs included in this meta-analysis comparing posterior reconstruction with “no reconstruction” showed no effect on early continence rates [6,15]. The other studies that are responsible for the positive effect were nonrandomized cohort studies [23–26]. From this point of view, there is currently no definitive evidence that posterior reconstructions have a positive impact on early functional outcomes after RARP.

In 2009, Patel et al. [8] showed that the technique of anterior reconstruction through anchoring the urethra and urethral supportive structures to the pubic bone could improve functional outcomes at 3 mo postoperatively in those undergoing RARP compared with a nonrandomized control group. The effect did not last as the continence rates were similar to those in the control group at 6 and 12 mo postoperatively. Different modifications to the original concepts of anterior and posterior reconstructions have been adopted since, with promising continence rates [10,11,27–31]. From small RCTs, it seems that a combined anterior and posterior or total reconstruction has advantage over the standard technique at 1 or 3 mo after RARP [9,11,17–19], whereas long-term outcomes are unknown and have largely not been supported by RCTs [9,17–19,27–31].

One of the difficulties in comparing different patient series and modification techniques is that different nomenclatures exist for the same reconstructive procedure. As the anatomical structures on the posterior aspect of the bladder wall and on the posterior side of the urethra are sometimes hard to distinguish from one another, it might well be that different modifications are based on a similar reconstructive concept. Otherwise, the same nomenclature is sometimes given for modifications of different reconstructive techniques. For instance, anterior reconstruction might be reserved for techniques that anchor the urethra to the pubic fascia or, alternatively, for fixation of the periurethral tissues to the bladder neck and endopelvic fascia.

MUL on preoperative magnetic resonance imaging (MRI) has been linked to improved continence outcomes at 6 and 12 mo after radical prostatectomy [32]. MUL is measured via T2-weighted MR images and defined as the distance from the prostatic apex to the entry of the urethra into the penile bulb [33]. It is one of the nonmodifiable, patient-related anatomical factors that has been reported to affect continence rates following RARP. In a meta-analysis, Mungovan et al. [34] found that greater preoperative MUL has a significant positive effect on overall time to continence recovery. Therefore, MUL may be of potential value to clinicians and patients in understanding the likely time course for the control of SUI after surgery. Indeed, in different smaller patient series, it was shown that any technique that increases the length of the (residual) functional urethra might lead to a quicker recovery to continence [14,35].

Table 2 – Surgical reconstructive techniques and outcomes of continence at approximately 1, 3, and 12 mo after robot-assisted radical prostatectomy

Surgical reconstructive procedure	Type of study	Definition of continence	No. of patients	Technique	Continence rates at 1 mo, *n* (%)	Continence rates at 3 mo, *n* (%)	Continence rates at 12 mo, *n* (%)
Posterior reconstruction of the rhabdomyosphincter							
Rocco (2007) [4][a]	n-RCT	No pads or 1 safety pad	31	Posterior reconstruction	26 (83.8)	24 (92.3)	ND
			31	Standard surgery	10 (32.3)	20 (76.9)	ND
Nguyen (2008) [23]	C	0–1 pad	32	Posterior reconstruction	18 (56.0)[b]	ND	ND
			30	No reconstruction	5 (17.0)[b]	ND	ND
Joshi (2010) [6]	RCT	No pads	53	Posterior reconstruction	ND	28 (52.0)	ND
			54	No reconstruction	ND	34 (63.0)	ND
Coelho (2011) [24]	C	No pads	472	Posterior reconstruction	244 (51.6)	431 (91.1)	ND
			330	No reconstruction	141 (42.7)	303 (91.8)	ND
Jeong (2012) [25]	C	No pads	116	Posterior reconstruction	66 (58.4)	91 (82.7)	ND
			126	No reconstruction	53 (45.7)	79 (70.5)	ND
Ogawa (2017) [16]	RCT	1-h pad test <5 g	24	Modified posterior reconstruction	14 (57.0)	18 (74.0)	21 (89.0)
			24	Posterior reconstruction	6 (26.0)	17 (71.0)	22 (91.0)
You (2012) [26]	C	No pads or 1 safety pad (<50 ml)	28	Posterior reconstruction	16 (57.2)	25 (89.2)	ND
			31	No reconstruction	11 (35.5)	22 (71.0)	ND
Sutherland (2011) [15]	RCT	No pads or one security pad	47	Posterior reconstruction	19 (42.0)[b]	29 (63.0)	ND
			47	Standard technique	18 (43.0)[b]	33 (81.0)	ND
Periurethral suspension stitch							
Patel (2009) [8]	n-RCT	No pads, no leakage of urine	237	Suspension stitch	95 (40.0)	220 (92.8)	232 (97.9)
			94	No suspension	31 (33.0)	78 (83.0)	90 (95.7)
Anterior suspension and posterior reconstruction technique							
Hurtes (2012) [9]	RCT	No pads	34	Anterior and posterior reconstruction	9 (26.5)	14 (45.2)	ND
			28	No reconstruction	2 (7.1)	4 (15.4)	ND
Menon (2008) [17]	RCT	0–1 pad (<30 g/d)	59	Anterior and posterior reconstruction	47 (80.0)	ND	ND
			57	No reconstruction	42 (74.0)	ND	ND
Koliakos (2010) [19]	RCT	“Dry”	23	Anterior and posterior reconstruction	ND	15 (23.0)[c]	ND
			24	No reconstruction	ND	8 (34.7)	ND
Tan (2010) [10]	C	No pads or one security pad	1383	Anterior and posterior reconstruction	968 (70.0)	1268 (91.7)	1355 (98.0)
			214	No reconstruction	75 (35.2)	132 (61.9)	176 (82.1)
Sammon (2010) [18]	RCT	No pads	59	Anterior and posterior reconstruction	47 (80.0)	ND	ND
			57	Posterior reconstruction	47 (82.6)	ND	ND
Atug (2012) [27]	n-RCT	No pad or 1 dry pad	125	Anterior and posterior reconstruction	91 (72.8)	101 (80.8)	114 (91.2)
			120	No reconstruction	59 (49.1)	92 (76.6)	106 (88.3)
Kalisvaart (2009) [28]	C	0–1 pad per day	50	Anterior and posterior reconstruction	ND	15 (42.0)	ND
			50	No reconstruction	ND	8 (20.6)	ND
Han (2015) [29]	C	No pads, no leakage	60	Anterior reconstruction	15 (25.0)	36 (60.0)	ND
			70	No reconstruction	16 (23.9)	40 (57.7)	ND
Beattie (2013) [30]	C	No pads, no leakage	81	Anterior and posterior reconstruction	17 (20.5)[b]	36 (44.3)	ND
			51	Posterior reconstruction	4 (8.2)[b]	14 (26.7)	ND
Advanced reconstruction of vesicourethral support (ARVUS)							
Student (2017) [11]	RCT	ICIQ-SF score ≤ 6 and 0 pads used per day	32	ARVUS	20 (62.5)	22 (68.8)[d]	26 (86.7)
			34	Posterior reconstruction	5 (14.7)	7 (20.6)[d]	19 (61.3)
Dal Moro (2014) [31]	n-RCT	ICIQ-SF ≤ 6	18	CORPUS technique	15 (83.0)	ND	ND
			18	Posterior reconstruction	11 (61.0)	ND	ND
Total anatomical reconstruction (TAR)							
Porpiglia (2016) [12]	C	No pad or 1 safety pad	252	TAR	225 (89.3)	238 (94.4)	247 (98.0)
			NP	NP	NP	NP	NP
Modified urethral length preservation (MULP)							
Hamada (2014) [13]	n-RCT	No pads	30	MULP	21 (70.0)	29 (96.6)	100 (100.0)
			30	Posterior reconstruction	3 (10.0)	7 (23.3)	16 (53.3)
Bladder-neck preservation							
Freire (2009) [14]	C	No pads	348	Bladder-neck preservation	ND	227 (65.6)	108 (86.4)
			223	Standard technique	ND	59 (26.5)	104 (81.4)
Gu (2015) [35]	C	No pads	233	Bladder-neck preservation	82 (36.0)[b]	152 (69.1)	190 (94.6)
			NP	NP	NP	NP	

C = retrospective cohort study; CORPUS = complete reconstruction of posterior urethral support; n-RCT = nonrandomized clinical trial; ND = no data; NP = not present; RCT = randomized clinical trial.

[a] Conventional laparoscopic radical prostatectomy.

[b] At 6 wk postoperatively.

[c] At 7 wk postoperatively.

[d] At 8 wk postoperatively.

It is striking that all described reconstructive techniques show good-to-excellent outcomes 1 yr after surgery, that is, continence rates between 87% and 98% of cases (Table 2). Apparently, all reconstructive surgical techniques result in similar short-term continence rates, without significant differences in long-term continence rates as compared with "no reconstruction." Only few RCTs have compared a particular reconstructive technique with "no reconstruction" or a different reconstructive technique. The RCTs showed conflicting results when functional outcome rates were compared [6,9,11,15–19], and despite the finding that the only meta-analysis on posterior reconstruction in RARP is suggestive in favor of using these techniques, it might be hampered by inherent biases comparing cohorts without randomization [3]. Yet, as restoring anatomy is generally considered a basic principle of reconstructive surgery, one can advocate that this might justify its use as all reconstructive techniques seem feasible and safe.

It might well be that functional outcomes may be dependent on transitory neuropraxia due to (counter) traction on the neurovascular bundle by the suction tip or robotic instruments [36,37]. Stretch neuropathy by lateral displacement of the neurovascular bundle was shown to be related to delayed and diminished sexual function, and might intuitively lead to short-term incontinence as well [37]. To answer this question definitely, we need RCTs that compare different reconstructive techniques or maybe a reconstructive technique with "no reconstruction, no tension on the neurovascular bundles technique".

5. Conclusions

All the aforementioned reconstructions aim at restoring normal anatomical and functional relationships in the pelvic floor to reduce SUI rates and the time to achieve continence. Although many of the procedures report a benefit with respect to early continence, the benefits seem to diminish with longer follow-up. Whether anterior or posterior reconstruction (or combinations) of the pelvic floor, bladder-neck reconstruction, or enhancement of urethral length is superior to one another is a matter of study. Larger randomized studies comparing different techniques are lacking and eagerly awaited.

Author contributions: André N. Vis 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: Vis, Nieuwenhuijzen.
Acquisition of data: Vis, Ruiter.
Analysis and interpretation of data: Vis, van der Poel, Nieuwenhuijzen.
Drafting of the manuscript: Vis, Ruiter.
Critical revision of the manuscript for important intellectual content: Vis, van der Poel, Ruiter, Hu, Tewari, Rocco, Patel, Razdan, Nieuwenhuijzen.
Statistical analysis: Vis, Nieuwenhuijzen.
Obtaining funding: None.
Administrative, technical, or material support: Vis, van der Poel, Hu, Tewari, Rocco, Patel, Razdan.
Supervision: Vis, Nieuwenhuijzen.
Other: None.

Financial disclosures: André N. Vis certifies that all conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript (eg, employment/affiliation, grants or funding, consultancies, honoraria, stock ownership or options, expert testimony, royalties, or patents filed, received, or pending), are the following: None.

Funding/Support and role of the sponsor: Research performed by Dr. Jim C. Hu was supported by The Frederick J. and Theresa Dow Wallace Fund of the New York Community Trust.

Acknowledgments: Anatomical illustrations were made by Rogier Trompert Medical Art (http://www.medical-art.eu). Video compilation was made in association with Roel Millenaar (https://vimeo.com/roelmillenaar). Video footage was sound recorded by Benjamin Tros, a medical student and native English speaker.

Appendix A. Supplementary data

The Surgery in Motion video accompanying this article can be found in the online version at https://doi.org/10.1016/j.eururo.2018.11.035 and via www.europeanurology.com.

References

[1] Ficarra V, Novara G, Rosen RC, et al. Systematic review and meta-analysis of studies reporting urinary continence recovery after robot-assisted radical prostatectomy. Eur Urol 2012;62:405–17.

[2] Schlomm T, Heinzer H, Steuber T, et al. Full functional-length urethral sphincter preservation during radical prostatectomy. Eur Urol 2011;60:320–9.

[3] Grasso AA, Mistretta FA, Sandri M, et al. Posterior musculofascial reconstruction after radical prostatectomy: an updated systematic review and a meta-analysis. BJU Int 2016;118:20–34.

[4] Rocco B, Gregori A, Stener S, et al. Posterior reconstruction of the rhabdosphincter allows a rapid recovery of continence after transperitoneal videolaparoscopic radical prostatectomy. Eur Urol 2007;51:996–1003.

[5] Gautam G, Rocco B, Patel VR, Zorn KC. Posterior rhabdosphincter reconstruction during robot-assisted radical prostatectomy: critical analysis of techniques and outcomes. Urology 2010;3:734–41.

[6] Joshi N, de Blok W, van Muilekom E, van der Poel H. Impact of posterior musculofascial reconstruction on early continence after robot-assisted laparoscopic radical prostatectomy: results of a prospective parallel group trial. Eur Urol 2010;58:84–9.

[7] Walsh PC. Anatomical radical prostatectomy: evolution of the surgical technique. J Urol 1998;160:2418–24.

[8] Patel VR, Coelho RF, Palmer KJ, Rocco B. Periurethral suspension stitch during robot-assisted laparoscopic radical prostatectomy: description of the technique and continence outcomes. Eur Urol 2009;56:472–8.

[9] Hurtes X, Roupret M, Vaessen C, et al. Anterior suspension combined with posterior reconstruction during robot-assisted laparoscopic prostatectomy improves early return of continence: a prospective randomized multicenter trial. BJU Int 2012;110:875–83.

[10] Tan G, Srivastava A, Grover S, et al. Optimizing vesicourethral anastomosis healing after robot-assisted laparoscopic radical prostatectomy: lessons learned from three techniques in 1900 patients. J Endourol 2010;24:1975–83.

[11] Student Jr V, Vidlar A, Grepl M, Hartmann I, Buresova E, Student V. Advanced reconstruction of vesicourethral support (ARVUS) during robot-assisted radical prostatectomy: one-year functional outcomes in a two-group randomised controlled trial. Eur Urol 2017;71:822–30.

[12] Porpiglia F, Bertolo R, Manfredi M, et al. Total anatomical reconstruction during robot-assisted radical prostatectomy: implications on early recovery of urinary continence. Eur Urol 2016;69:485–95.

[13] Hamada A, Razdan S, Etafy MH, Fagin R, Razdan S. Early return of continence in patients undergoing robot-assisted laparoscopic prostatectomy using modified maximal urethral length preservation technique. J Endourol 2014;28:930–8.

[14] Freire MP, Weinberg AC, Lei Y, et al. Anatomic bladder neck preservation during robotic-assisted laparoscopic radical prostatectomy: description of technique and outcomes. Eur Urol 2009;56:972–80.

[15] Sutherland DE, Linder B, Guzman AM, et al. Posterior rhabdosphincter reconstruction during robotic assisted radical prostatectomy: results from a phase II randomized clinical trial. J Urol 2011;185:1262–7.

[16] Ogawa S, Hoshi S, Koguchi T, et al. Three-layer two-step posterior reconstruction using peritoneum during robot-assisted radical prostatectomy to improve recovery of urinary continence: a prospective comparative study. J Endourol 2017;31:1251–7.

[17] Menon M, Muhletaler F, Campos M, Peabody JO. Assessment of early continence after reconstruction of the periprostatic tissues in patients undergoing computer assisted (robotic) prostatectomy: results of a 2 group parallel randomized controlled trial. J Urol 2008;180:1018–23.

[18] Sammon JD, Muhletaler F, Peabody JO, Diaz-Insua M, Satyanaryana R, Menon M. Long-term functional urinary outcomes comparing single-vs double-layer urethrovesical anastomosis: two-year follow-up of a two-group parallel randomized controlled trial. Urology 2010;76:1102–7.

[19] Koliakos N, Mottrie A, Buffi N, De Naeyer G, Willemsen P, Fonteyne E. Posterior and anterior fixation of the urethra during robotic prostatectomy improves early continence rates. Scand J Urol Nephrol 2010;44:5–10.

[20] Chang JI, Lam V, Patel MI. Preoperative pelvic floor muscle exercise and postprostatectomy incontinence: a systematic review and meta-analysis. Eur Urol 2016;69:460–7.

[21] Michl U, Tennstedt P, Feldmeier L, et al. Nerve-sparing surgery technique, not the preservation of the neurovascular bundles, leads to improved long-term continence rates after radical prostatectomy. Eur Urol 2016;69:584–9.

[22] Lei Y, Alemozaffar M, Williams SB, et al. Athermal division and selective suture ligation of the dorsal vein complex during robot-assisted laparoscopic radical prostatectomy: description of technique and outcomes. Eur Urol 2011;59:235–43.

[23] Nguyen MM, Kamoi K, Stein RJ, et al. Early continence outcomes of posterior musculofascial plate reconstruction during robotic and laparoscopic prostatectomy. BJU Int 2008;101:1135–9.

[24] Coelho RF, Chauhan S, Orvieto MA, et al. Influence of modified posterior reconstruction of the rhabdosphincter on early recovery of continence and anastomotic leakage rates after robot-assisted radical prostatectomy. Eur Urol 2011;59:72–80.

[25] Jeong CW, Oh JJ, Jeong SJ, et al. Novel posterior reconstruction technique during robot-assisted laparoscopic prostatectomy: description and comparative outcomes. Int J Urol 2012;19:683–7.

[26] You YC, Kim TH, Sung GT. Effect of bladder neck preservation and posterior urethral reconstruction during robot-assisted laparoscopic radical prostatectomy for urinary continence. Korean J Urol 2012;53:29–33.

[27] Atug F, Kural AR, Tufek I, Srivastav S, Akpinar H. Anterior and posterior reconstruction technique and its impact on early return of continence after robot-assisted radical prostatectomy. J Endourol 2012;26:381–6.

[28] Kalisvaart JF, Osann KE, Finley DS, Ornstein DK. Posterior reconstruction and anterior suspension with single anastomotic suture in robot-assisted laparoscopic radical prostatectomy: a simple method to improve early return of continence. J Robot Surg 2009;3:149–53.

[29] Han KS, Kim CS. Effect of pubovesical complex reconstruction during robot-assisted laparoscopic prostatectomy on the recovery of urinary continence. J Laparoendosc Adv Surg Tech A 2015;25:814–20.

[30] Beattie K, Symons J, Chopra S, et al. A novel method of bladder neck imbrication to improve early urinary continence following robotic-assisted radical prostatectomy. J Robot Surg 2013;7:193–9.

[31] Dal Moro F, Crestani A, Valotto C, Zattoni F. CORPUS—novel COmplete Reconstruction of the Posterior Urethral Support after robotic radical prostatectomy: preliminary data of very early continence recovery. Urology 2014;83:641–7.

[32] Coakley FV, Eberhardt S, Kattan MW, Wei DC, Scardino PT, Hricak H. Urinary continence after radical retropubic prostatectomy: relationship with membranous urethral length on preoperative endorectal magnetic resonance imaging. J Urol 2002;168:1032–5.

[33] Myers RP, Cahill DR, Devine RM, King BF. Anatomy of radical prostatectomy as defined by magnetic resonance imaging. J Urol 1998;159:2148–58.

[34] Mungovan SF, Sandhu JS, Akin O, Smart NA, Graham PL, Patel MI. Preoperative membranous urethral length measurement and continence recovery following radical prostatectomy: a systematic review and meta-analysis. Eur Urol 2017;71:368–78.

[35] Gu X, Araki M, Wong C. Continence outcomes after bladder neck preservation during robot-assisted laparoscopic prostatectomy (RALP). Minim Invasive Ther Allied Technol 2015;24:364–71.

[36] Kowalczyk KJ, Huang AC, Hevelone AD, et al. Stepwise approach for nerve sparing without countertraction during robot-assisted radical prostatectomy: technique and outcomes. Eur Urol 2011;60:536–47.

[37] Mattei A, Naspro R, Annino F, Burke D, Guida Jr R, Gaston R. Tension and energy-free robotic-assisted laparoscopic radical prostatectomy with interfascial dissection of the neurovascular bundle. Eur Urol 2007;52:687–94.

EUROPEAN UROLOGY 79 (2021) 839–857

available at www.sciencedirect.com
journal homepage: www.europeanurology.com

European Association of Urology

Surgery in Motion

Retzius-sparing Robot-assisted Radical Prostatectomy Leads to Durable Improvement in Urinary Function and Quality of Life Versus Standard Robot-assisted Radical Prostatectomy Without Compromise on Oncologic Efficacy: Single-surgeon Series and Step-by-step Guide

Jillian Egan[a], *Shawn Marhamati*[a], *Filipe L.F. Carvalho*[a], *Meghan Davis*[a], *John O'Neill*[a], *Harry Lee*[a], *John H. Lynch*[a], *Ryan A. Hankins*[a], *Jim C. Hu*[b], *Keith J. Kowalczyk*[a,*]

[a] *Department of Urology, MedStar Georgetown University Hospital, Washington, DC, USA;* [b] *Department of Urology, Weill Cornell Medicine, New York, NY, USA*

Article info

Article history:
Accepted May 12, 2020

Associate Editor
:Alexandre Mottrie

Keywords:
Robotic-assisted surgery
Retzius sparing prostatectomy
Urinary function
Incontinence
Outcomes
Prostate cancer

Please visit www.europeanurology.com and www.urosource.com to view the accompanying video.

Abstract

Background: Retzius-sparing robot-assisted radical prostatectomy (RS-RARP) has been shown to improve continence. However, questions remain regarding feasibility and generalizability of technique and outcomes.

Objective: To compare the outcomes of 140 consecutive standard robot-assisted radical prostatectomy (S-RARP) versus RS-RARP.

Design, setting, and participants: A total of 70 S-RARPs were performed followed by 70 RS-RARPs. Demographic, pathologic, and functional outcomes were compared preoperatively and through 12 mo. Expanded Prostate Cancer Index Composite for Clinical Practice (EPIC-CP) was used to compare functional outcomes. Logistic and linear regression analyses were utilized to analyze variables associated with EPIC-CP urinary incontinence and overall quality of life (QOL) scores, and oncologic outcomes. Cox regression analysis was used to analyze incontinence at 12 mo.

Surgical procedure: RS-RARP versus S-RARP.

Measurements: Patient and tumor characteristics (age, body mass index, prostate-specific antigen, Charlson Comorbidity Index, Gleason group, clinical stage, and Prostate Imaging Reporting and Data System score), perioperative outcomes (console time, estimated blood loss, postoperative complications, and length of stay), oncologic outcomes (positive surgical margin [PSM], and biochemical recurrence), overall and 12-mo continence rates (zero pads and zero to one safety pad), time to continence, potency (erection sufficient for sexual activity), EPIC-CP urinary incontinence, sexual function, and overall QOL scores.

Results and limitations: Median follow-up for S-RARP versus RS-RARP was 46.3 versus 12.3 mo. RS-RARP versus S-RARP had improved overall continence rates at total follow-up (95.7% vs 85.7%, $p = 0.042$) and 12-mo follow-up (97.6% vs 81.4%, $p = 0.002$), and faster return to continence (zero to one safety pad, 44 vs 131 d, $p < 0.001$). RS-RARP EPIC-CP urinary incontinence and overall QOL scores remained significantly better at 12 mo. There were no differences in overall PSM rates, although RS-RARP had lower rates of nonfocal PSMs. There were no differences in sexual function. In multivariate analysis,

---

[*] Corresponding author. Department of Urology, Georgetown University Medical Center, Lombardi Cancer Center, MedStar Georgetown University Hospital, Washington, DC, USA.
Tel. +1-202-444-4922, Fax: +1-877-625-1478.
E-mail address: keith.kowalczyk@medstar.net (K.J. Kowalczyk).

https://doi.org/10.1016/j.eururo.2020.05.010

RS-RARP was significantly associated with improved 12-mo EPIC-CP urinary incontinence and improved QOL scores, but was not associated with PSM or biochemical recurrence. Limitations include retrospective study design and unequal follow-up; however, significantly better RS-RARP continence at 12 mo is striking despite fewer patients attaining 12-mo follow-up.

Conclusions: RS-RARP significantly improves early and long-term continence without compromising oncologic outcomes and leads to overall improved QOL.

Patient summary: Retzius-sparing robot-assisted radical prostatectomy is an emerging technique for robotic radical prostatectomy that improves urinary function and quality of life without compromising cancer control.

1. Introduction

Urinary incontinence following radical prostatectomy (RP) is a significant and perhaps under-reported long-term consequence that substantially decreases quality of life (QOL) [1]. For instance, the United States Preventative Services Task Force (USPSTF) cites urinary incontinence among the harms of prostate-specific antigen (PSA) screening, and the USPSTF infographic [2] quotes a 19% incontinence rate after RP.

In 2010, Galfano et al [3] described Retzius-sparing robot-assisted radical prostatectomy (RS-RARP), which demonstrated improved short-term continence [4,5]. However, urologists have been slow to adopt RS-RARP, with a recent poll of 250 respondents demonstrating only 10.8% of RP performed with this approach [6], with specific comments regarding concerns of increased positive surgical margins (PSMs) and a lack of long-term differences in urinary function [5]. Therefore, further study is needed to demonstrate reproducibility of RS-RARP short-term outcomes, exhibit improved long-term outcomes, and confirm oncologic efficacy. In addition, detailed step-by-step RS-RARP guides are needed to disseminate technique and encourage widespread reproducibility. We present our RS-RARP versus standard robot-assisted radical prostatectomy (S-RARP) series comparing functional and oncologic outcomes, and also provide a step-by-step guide detailing our RS-RARP technique.

2. Patients and methods

2.1. Enrollment

A total of 140 consecutive RARPs (70 S-RARPs and 70 RS-RARPs) were performed by a single surgeon (K.J.K.) at our institution. In January 2018, the technique transitioned to RS-RARP, and 70 RS-RARPs were performed through January 2020. These cases were compared with the preceding 70 S-RARPs.

Prior to this study, 163 and 446 S-RARPs had been performed by the surgeon as an attending physician and a trainee, respectively. However, to ensure that there was no learning curve effect, Pearson correlation coefficient were calculated between estimated blood loss (EBL), urinary continence (zero to one pad), PSM, and Expanded Prostate Cancer Index Composite for Clinical Practice (EPIC-CP) urinary incontinence scores versus case number over the 70 S-RARPs analyzed. Only EBL was found to have a small but significant decrease over the series, while continence, PSM, and EPIC-CP urinary incontinence scores did not have any significant change, indicating minimal, if any, learning curve effect for these outcomes. Additionally, a prior study has shown little learning curve effect for surgeons changing from S-RARP to RS-RARP [7].

Our S-RARP technique has been described [8–11] and involves bladder neck (BN) preservation, endopelvic fascia preservation, tension-free nerve sparing, and urethral length preservation. We maintained these surgical techniques and principles while performing RS-RARP.

There were no contraindications to RS-RARP or S-RARP with regard to prior surgery, size of prostate, or salvage treatment. The largest prostate in this series was 115 g, and prior studies have shown no differences in RS-RARP outcomes based on prostate size [12]. We have also performed two salvage RS-RARPs without any increased difficulty or complications; however, these patients were excluded from the current study.

2.2. Surgical technique

Our RS-RARP technique replicates that of Galfano et al [3] with minor modifications. The DaVinci Si (Intuitive Surgical, Sunnyvale CA, USA) was used for all cases.

2.2.1. Robotic set-up and port placement

Port configuration for DaVinci Si platform is displayed in Fig. 1. In contrast to S-RARP, the left second robotic arm is medial and more caudal, at the level of the camera, to reduce arm collisions. Prograsp forceps are placed in this arm. Bipolar Maryland forceps are placed in the left lateral third robotic arm. Following the completion of this series, we have completed 15 additional RS-RARPs utilizing the DaVinci Xi platform and have not needed to make any major changes in the technique other than changing the camera port to a robotic 8 mm port, side docking of the patient cart, and the ability to change easily from the 30° down lens to the 30° up lens following the completion of the seminal vesicle (SV) dissection. Cautery is set at 35 W for monopolar and bipolar on the Si platform, and the ERBE VIO dV 2.0 generator cautery setting is adjusted to 3 for monopolar and bipolar on the Xi platform.

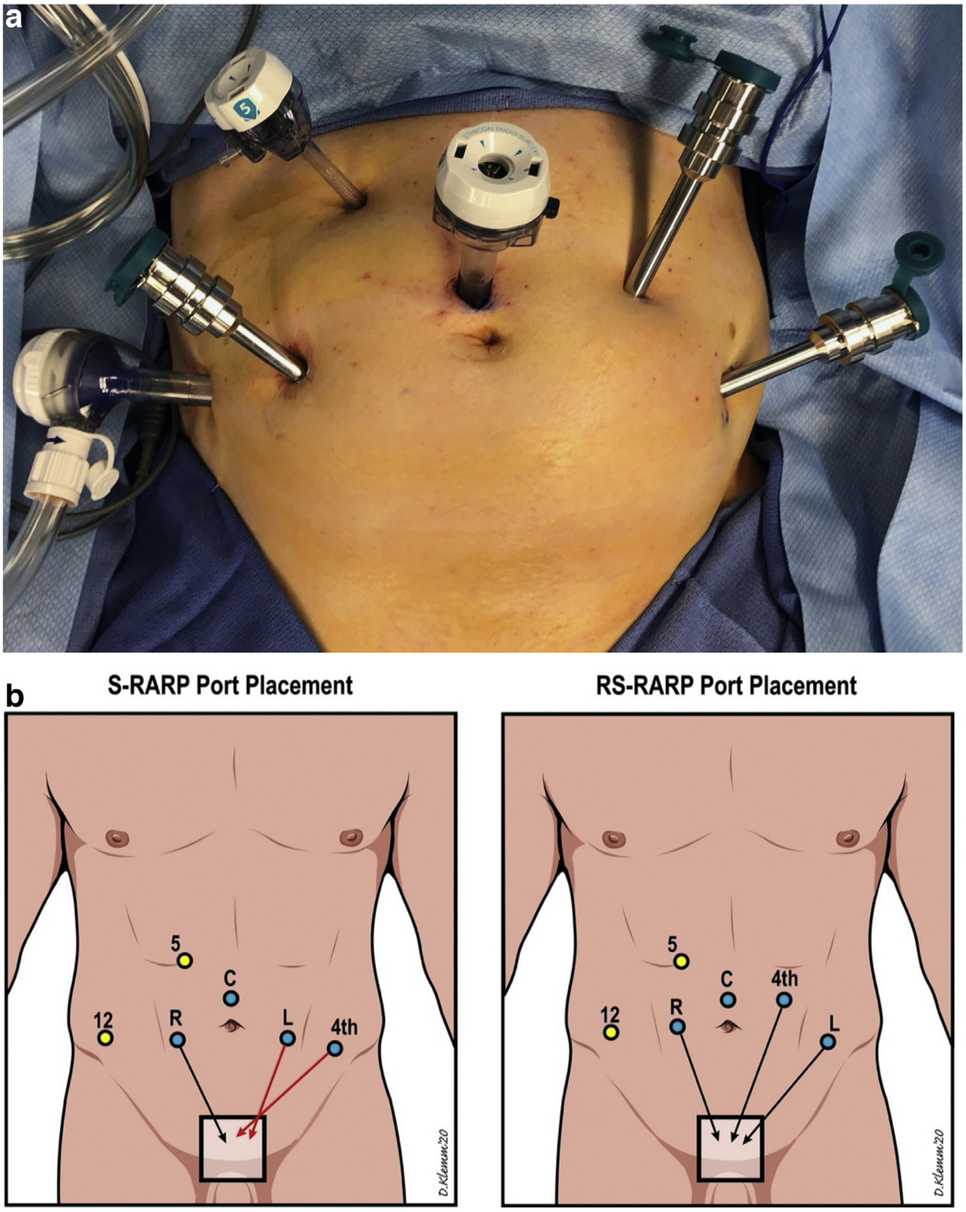


Fig. 1 – Schematic of port placement for both RS-RARP and S-RARP. For RS-RARP, the Prograsp forceps is placed in the left medial robotic port and in a more caudal position, as this minimizes instrument clashing in the small operative space. RS-RARP = Retzius-sparing robot-assisted radical prostatectomy; S-RARP = standard robot-assisted radical prostatectomy.

2.2.2. *Incision of the peritoneum, and vas deference and SV dissection*

The 0° or 30° lens can be used based on surgeon preference and patient anatomy. The sigmoid is gently mobilized superiorly, lysing lateral attachments for further mobilization if needed. A horizontal semicircular incision is made at the level of the vas deferens (VD) and SV, identified as an arch anterior to the rectum. Denonvillier's fascia (DF) is exposed posteriorly, and bilateral VD and SV are noted anteriorly. Each VD is dissected laterally and transected, with the SV commonly located inferior to the VD. The SV is bluntly dissected off DF until lateral arterioles are encountered and dissected with bipolar cautery and sharp dissection. Dissection is continued to the base of the prostate. Continual adjustment of gentle traction with the Prograsp is critical for exposure.

The 30° up lens is now used. Two 3-0 Prolene sutures on a Keith needle are placed through the anterior abdominal wall, through the anterior cut edge of peritoneum, and back through the abdomen for anterior peritoneal retraction (Fig. 2). The sutures are clamped extracorporeally. Prior to placing tension on these sutures, the SV and VD are tucked under the sutures and retracted, allowing free use of the Prograsp for the remainder of the procedure.

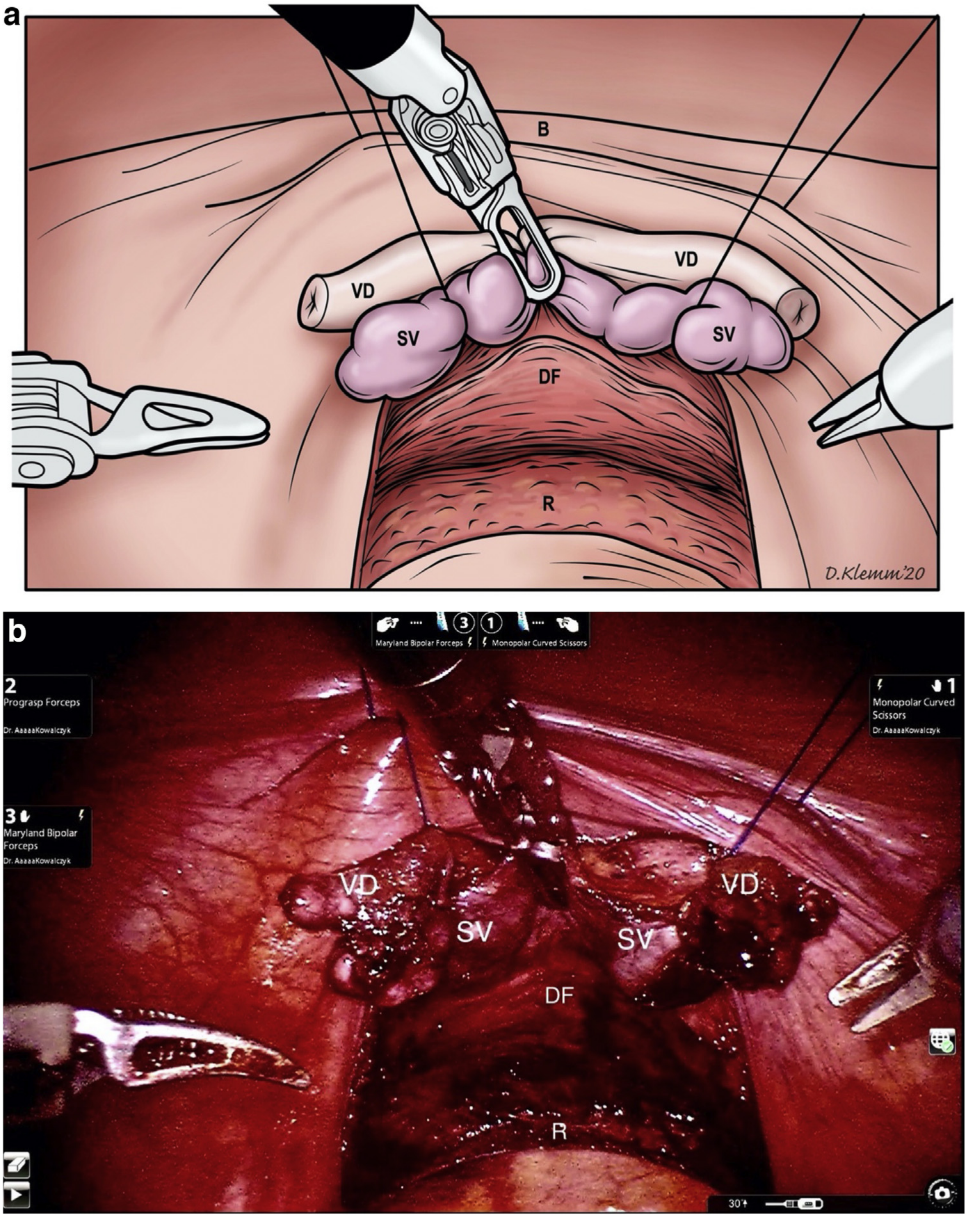


Fig. 2 – Exposure of posterior plane following VD and SV dissection and placement of anterior suspension sutures. B = bladder; DF = Denonvillier's fascia; R = rectum; SV = seminal vesicle; VD = vas deferens.

2.2.3. Posterior dissection

The posterior plane is developed by incising DF, and continuing dissection toward the apex and bilateral neurovascular bundles (NVBs). During intrafascial nerve sparing, this plane is continued as lateral as possible, directly on the surface of the prostate. We develop this plane more extensively during RS-RARP than during S-RARP, as it allows for identification of the prostatic arterial pedicles as dissection continues laterally.

2.2.4. Lateral pedicles and nerve sparing

The fourth arm is positioned at the base of the ipsilateral SV for gentle anteromedial retraction. The medial edge of the pedicle is encountered, and using the posterior prostate as a guide, a window is made laterally to skeletonize each arteriole, which is continually clipped as dissection is carried out anterolaterally (Fig. 3). Prostatic arterioles tend to be smaller than those encountered during S-RARP; therefore, smaller 5 mm clips (Aesculap, Tuttlingen, Germany) and gentle bipolar cautery are used. After pedicle dissection, the posterolateral intrafascial plane is encountered and the prostate is dissected from the remaining NVBs, avoiding traction (Fig. 4). With inter- or extrafascial approaches, a wider margin is taken. The Prograsp is continually repositioned as dissection is advanced toward the apex. Once the prostate is free posteriorly and laterally,

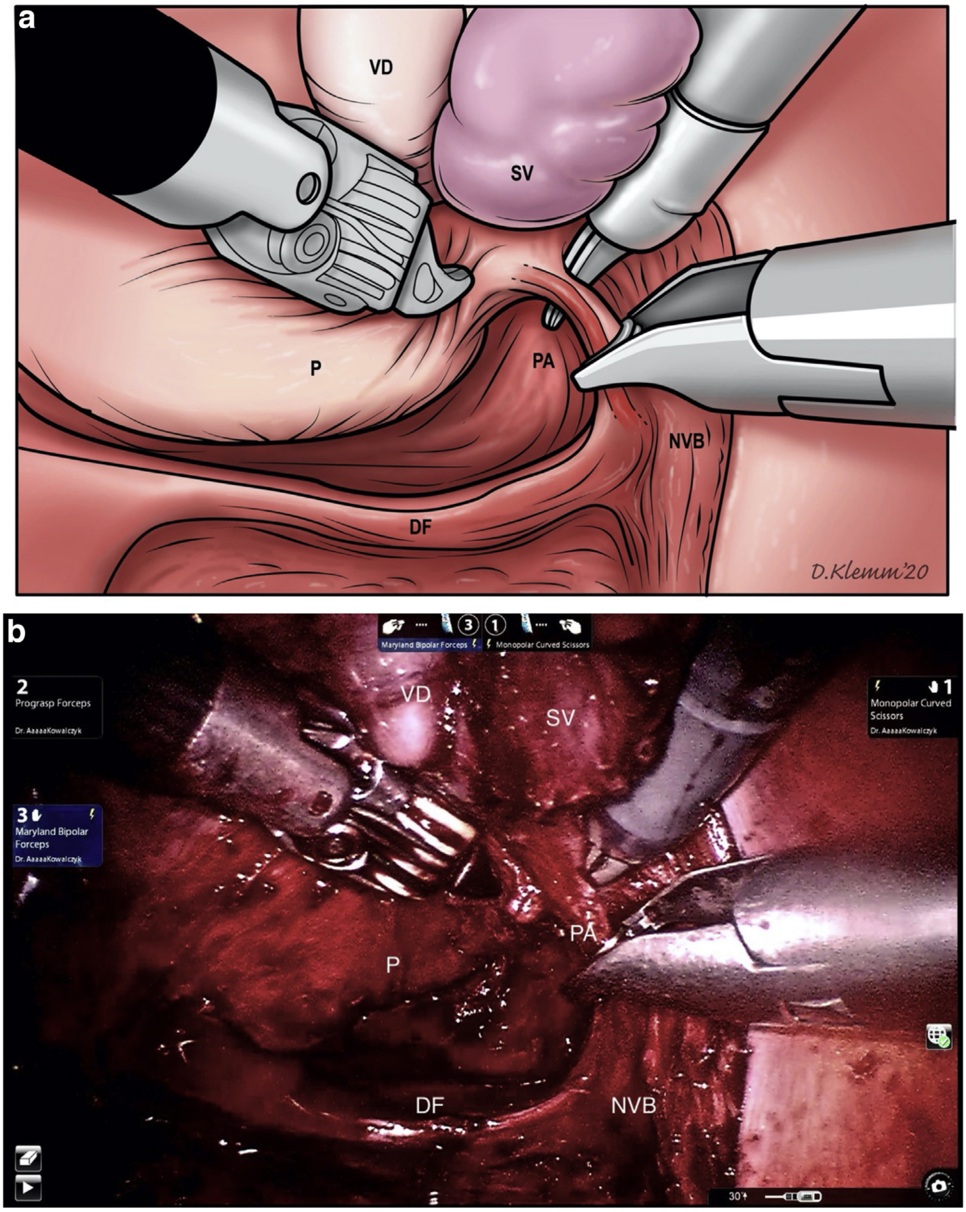


Fig. 3 – The right lateral prostatic pedicle is skeletonized and taken athermally with either small clips or bipolar cautery. The posterior prostate is used as a guide during this step as each arteriole is isolated. DF = Denonvillier's fascia; P = prostate; PA = prostatic artery; NVB = neurovascular bundle; SV = seminal vesicle; VD = vas deferens.

the ipsilateral SV and VD are removed from the retraction sutures and the prostate is approached anteriorly, where more arterioles may be found. The anterior detrusor apron is gently teased from the anterolateral prostate and apex (Fig. 5). This is repeated on the contralateral side.

2.2.5. Apex, BN, and anterior plane

Bilateral SV and VD are retracted posteriorly with the Prograsp. Detrusor fibers from the detrusor apron are identified inserting into the anterolateral prostate bilaterally. With left-handed upward traction on the bladder and posterior retraction with the Prograsp, detrusor fibers are gently dissected anteriorly off the prostate with blunt dissection and light monopolar cautery, with minimal contact with the tissue to avoid excessive tissue char or desiccation. This dissection is performed bilaterally, prior to dissecting the BN, in order to expose the apical and anterolateral prostate that is used as a guide for subsequent dissection. Carrying out of this anterior and apical dissection makes BN dissection easier. The prostate is gently retracted posteriorly, and the BN is identified and carefully dissected circumferentially, again with anterior retraction on the bladder and light monopolar cautery.

The BN is transected exposing the Foley catheter (Fig. 6), which is withdrawn, and the anterior BN mucosa is scored

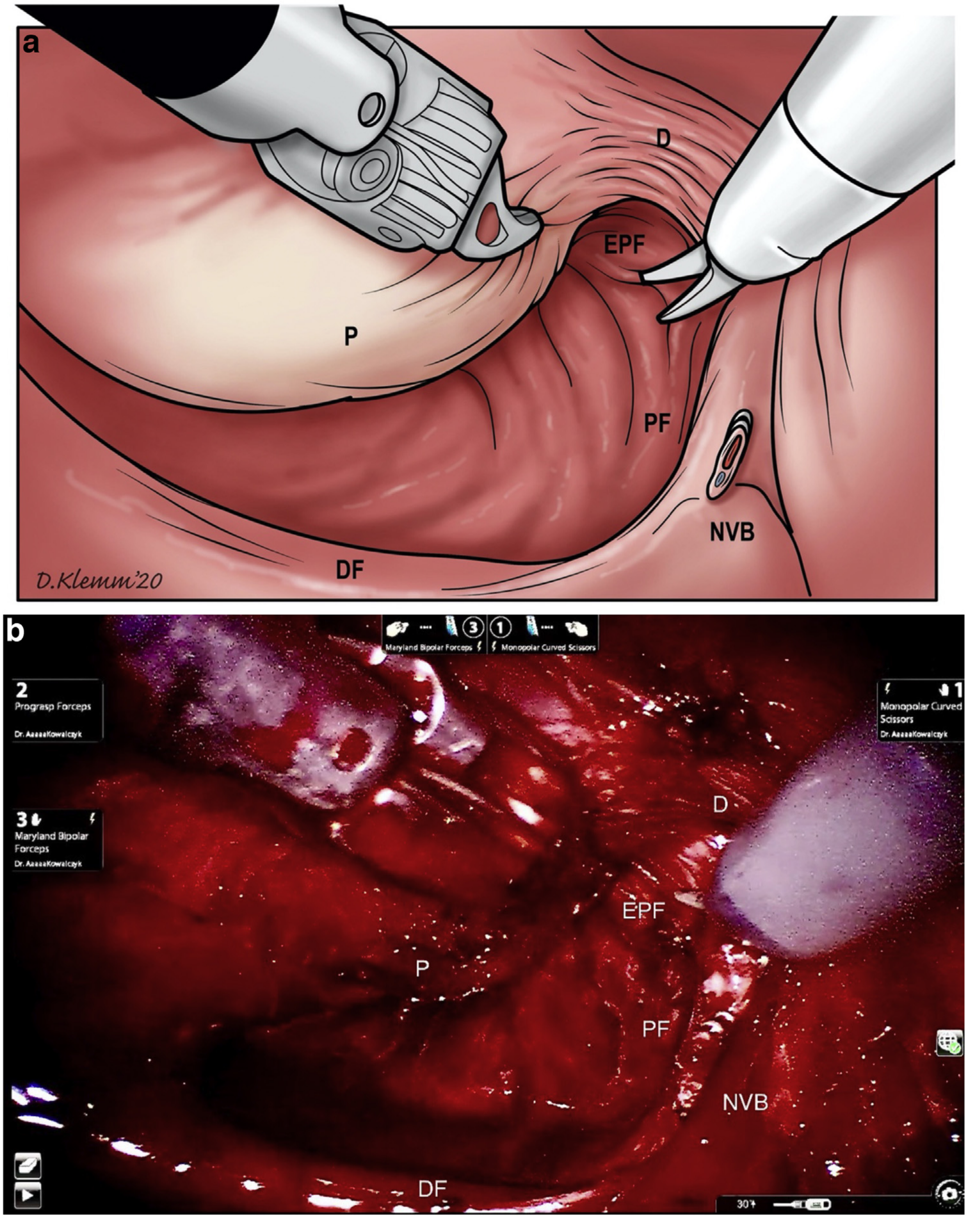


Fig. 4 – The avascular intrafascial plane is gently developed to the apex and also anteriorly, where the fibers of the detrusor apron are encountered. D = detrusor; DF = Denonvillier's fascia; EPF = endopelvic fascia; NVB = neurovascular bundle; P = prostate; PF = prostatic fascia.

with monopolar cautery. Beyond the BN, the anterior detrusor fibers are dissected with bipolar cautery and sharp dissection, to avoid dissecting into the incorrect surgical plane. The fourth arm is continually repositioned to provide downward traction, and the previously dissected anterolateral apex is used as a guide to maintain the correct surgical plane underneath the detrusor apron and dorsal venous complex (DVC; Fig. 7). The posterior DVC is entered if there is an anterior lesion. In our experience, DVC bleeding is minimal and rarely requires suturing, as this space is closed with vesicourethral anastomosis.

2.2.6. *Remaining apex and urethra*

The anterior urethra is encountered, and anatomy resembles S-RARP. The prostate is gently rotated bilaterally to dissect remaining apical attachments (Fig. 8). The urethra is developed into a large stump and sharply divided just distal to the apex.

2.2.7. *Anastomosis*

Needle drivers are placed in the first and second arms, leaving the Maryland bipolar forceps in the third arm for hemostasis. A 15 cm 3-0 V-Loc (Ethicon Inc., Somerville, NJ, USA) with CV-23 needle is placed through the anterior BN at

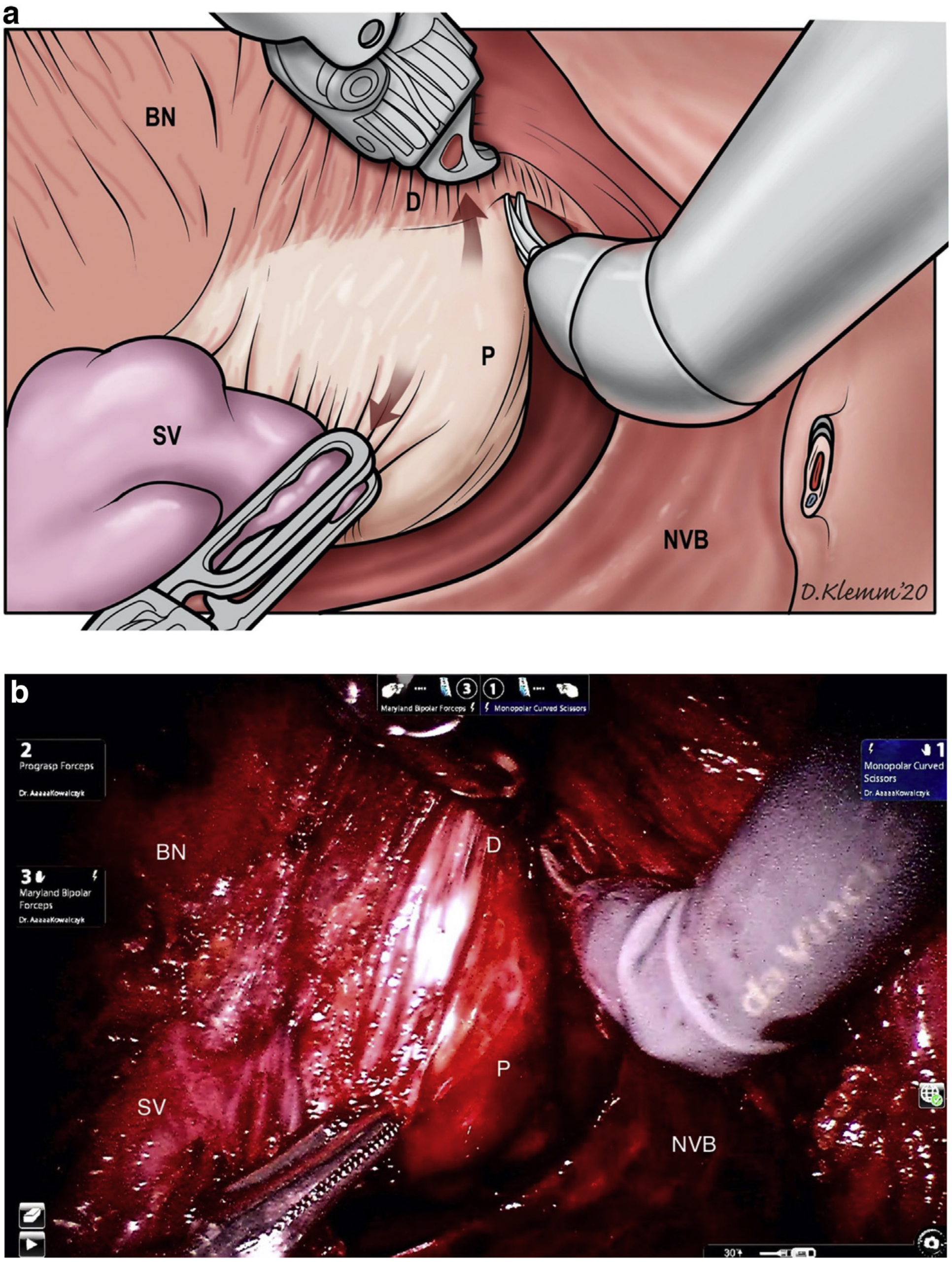


Fig. 5 – After taking the left-sided pedicle and nerve-sparing plane in similar manner, the anterolateral surface and apex of the prostate are further developed prior to dissecting the bladder neck. Continuous upward traction on the bladder with the left hand along with posterior retraction with the Prograsp will often reveal the interface between the detrusor fibers and prostate, and this is developed from the apex to the medial bladder neck utilizing gentle monopolar and blunt dissection. BN = bladder neck; D = detrusor; NVB = neurovascular bundle; P = prostate; SV = seminal vesicle.

the 1:00 position, outside to inside, and the needle is looped and secured to the BN. The suture is then placed through the anterior urethra from inside to outside, and the BN and urethra are brought together. Two more throws are taken in a counterclockwise direction to secure the anastomosis. A second 3-0 V-Loc suture is placed outside to inside on the anterior BN at 11:00 (Fig. 9). Both sutures are then run to 6:00. Prior to closing the posterior BN, the catheter is inserted across the anastomosis, which remains at a 90° “coude” angle to the urethra. This exposes the full length of the posterior urethral stump. The right sided suture is passed inside to outside through the posterior BN, and the sutures are tied together. The anastomosis is tested with 120 cc of saline irrigation, and drain is omitted if there is no leak. The urethral catheter is left for approximately 7 d following surgery, although prior studies have shown

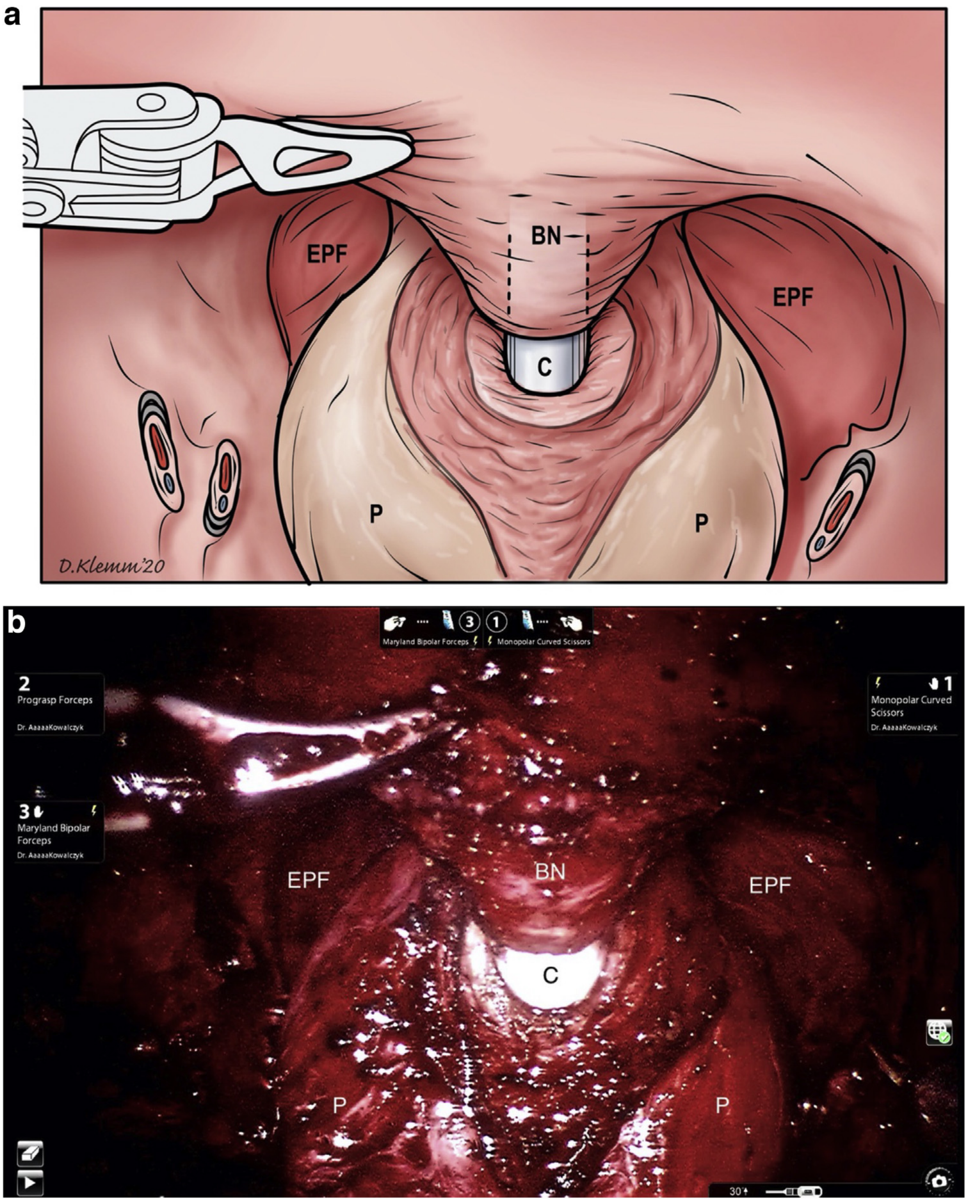


Fig. 6 – Only after dissecting the anterolateral prostate and apex from detrusor fibers, the bladder neck is dissected and transected, and the catheter is exposed. BN = bladder neck; C = catheter; EPF = endopelvic fascia; P = prostate.

feasibility of leaving a suprapubic cystotomy following RS-RARP as well [13].

2.2.8. Peritoneal closure

After ensuring hemostasis, the posterior peritoneum is closed using running 15 cm 3-0 V-Loc suture with V-20 needle. This contains potential postoperative urine leaks and provides tamponade in the event of postoperative bleeding, , although some surgeons do not make this closure watertight in the case of a significant hematoma that may disrupt the anastomosis (Christopher Eden, MD, personal correspondence, March 2020).

2.2.9. Lymph node dissection

Pelvic lymph node dissection is performed by making a longitudinal peritoneal incision at the junction of the VD and external iliac artery. The external iliac vein is identified, and the obturator lymph node packet is developed from the pelvic sidewall. Unlike S-RARP, the lymph node packet in RS-RARP is attached to the bladder medially and requires dissection from the bladder. The obturator nerve is identified and excluded. The anterior packet is clipped with 10 mm Weck Hem-O-Lok clips (Teleflex, Morrisville, NJ, USA), and the posterior packet is dissected away from the iliac bifurcation. This is repeated

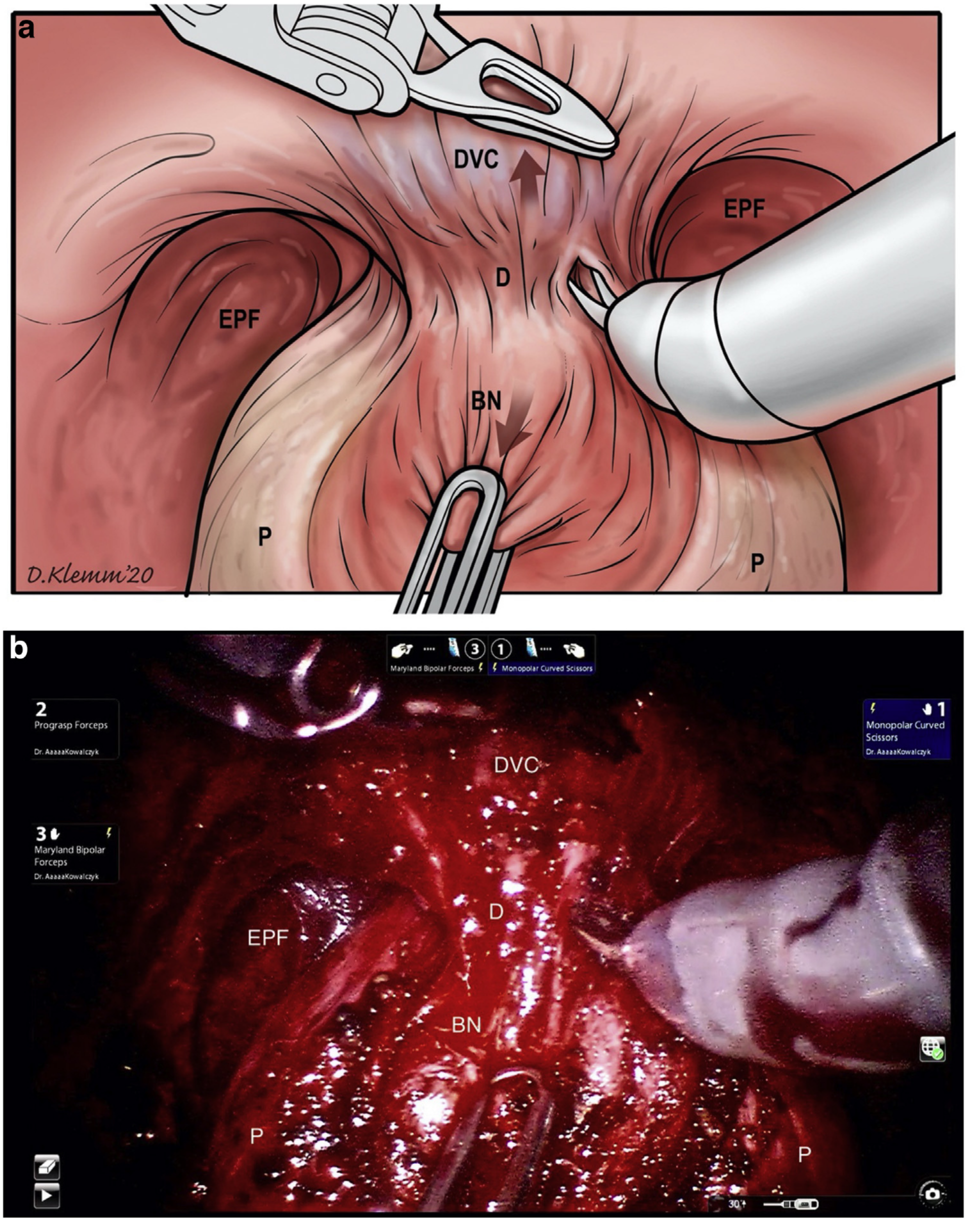


Fig. 7 – After transection of the bladder neck, the plane between the anterior prostate and the dorsal venous complex is developed. Blunt and bipolar dissection is helpful at this step in order to maintain the correct plan, and the apex is used as a visual guide during dissection. If necessary, the posterior portion of the DVC can be entered if the plane is difficult to establish or in men with anterior lesions. BN = bladder neck; D = detrusor; DVC = dorsal venous complex; EPF = endopelvic fascia; P = prostate.

on the contralateral side. Peritoneal incisions remain open to avoid lymphocele.

We do not routinely perform extended lymphadenectomy, although we perform standard lymphadenectomy to the level of the iliac bifurcation. We do not violate the Retzius space or transect the median umbilical ligament during lymph node dissection. When comparing those with versus without lymph node dissection, we have not noted any differences in urinary outcomes.

2.3. *Outcomes*

All outcomes were prospectively collected in an institutional review board–approved database by nonclinical research assistants. Patient demographics and tumor characteristics include age, body mass index (BMI), PSA, American Society of Anesthesiologists, Charlson Comorbidity Index (CCI), Gleason group (GG), clinical and pathologic stages, and magnetic resonance imaging (MRI) Prostate Imaging Reporting and

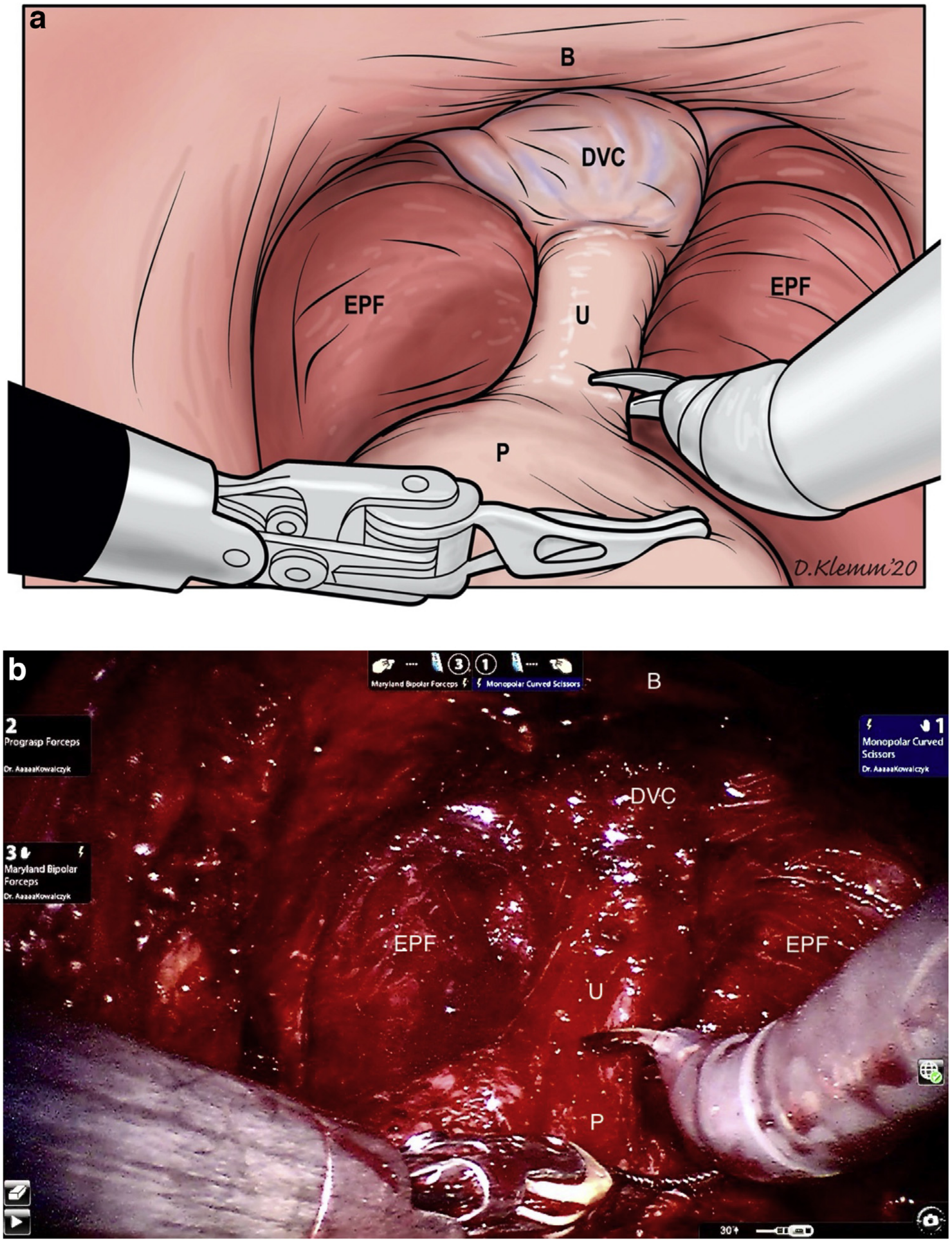


Fig. 8 – The urethra is eventually encountered, dissected, and cut in a similar manner to S-RARP. If necessary, openings in the posterior DVC can be selected ligated at this step; however, this is usually not necessary, as this space is closed with subsequent vesicourethral anastomosis. B = bladder; DVC = dorsal venous complex; EPF = endopelvic fascia; P = prostate; S-RARP = standard robot-assisted radical prostatectomy; U = urethra.

Data System (PIRADS) scores. Perioperative data included console time, EBL, postoperative complications, and length of stay. Long-term functional outcomes were assessed using the EPIC-CP, a validated questionnaire measuring five separate functional domains from 0 to 12, for a total score of 60, with lower scores representing better QOL [14]. Time to continence (both zero pads and zero to one safety pad) in days as well as binary assessment of both continence and potency (erection sufficient for sexual activity) was assessed. Oncologic outcomes included PSMs (focal [<3 mm] vs nonfocal [>3 mm]), need for adjuvant therapy, and biochemical recurrence (BCR; PSA $\geq$ 0.2). Finally, pentafecta outcomes (undetectable PSA, continence, potency, negative surgical margins, and lack of postoperative complications) were also measured and compared [15].

2.4. *Statistical analysis*

Wizard statistical software (Evan Miller; www.wizardmac.com) was used for statistical analysis. Wilcoxon rank sum, χ^2, Fisher exact, analysis of variance, and *t* tests were used for bivariate analyses. Stepwise logistic regression was performed to determine factors influencing PSM and BCR. Stepwise linear regression was performed to determine

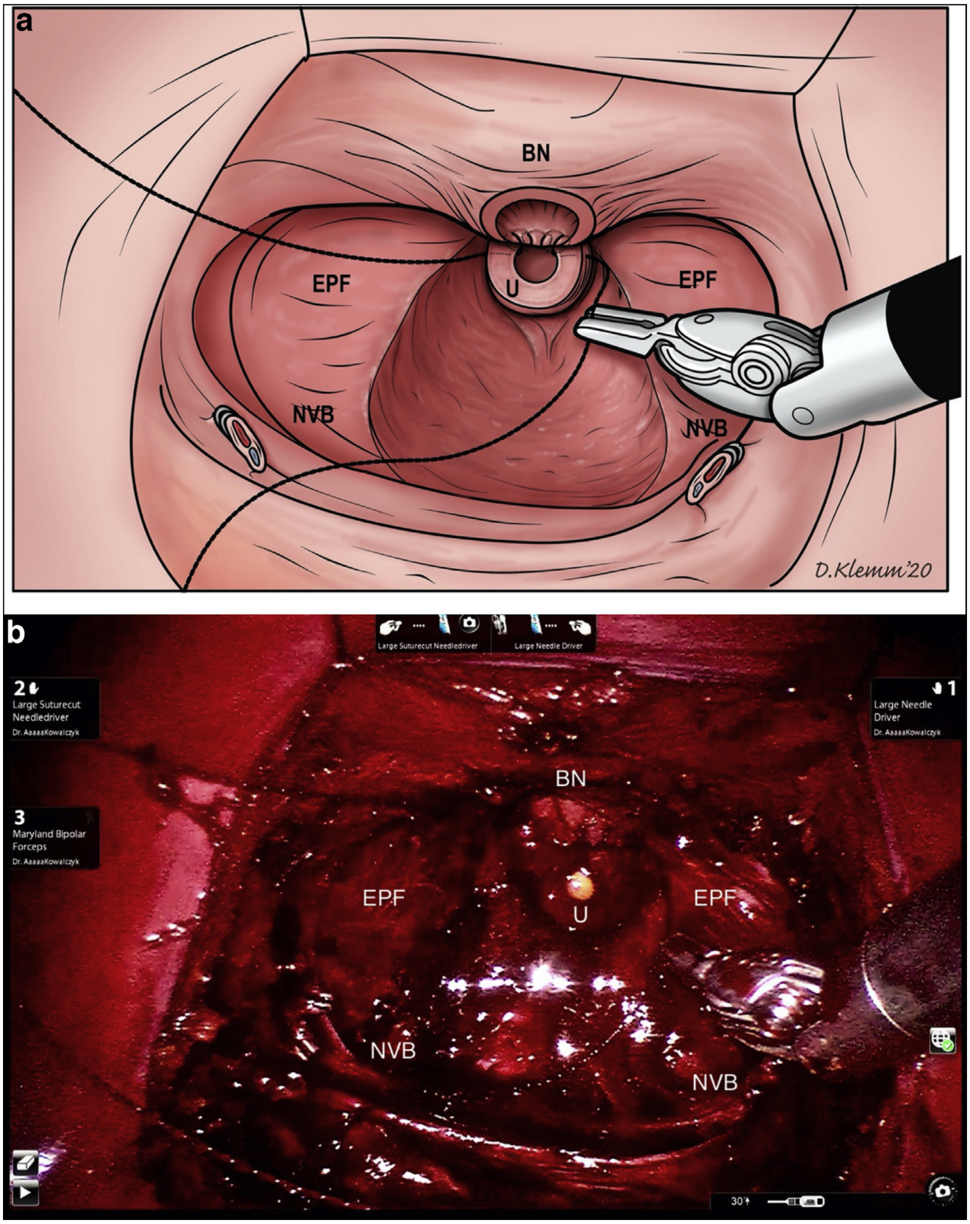


Fig. 9 – Use of two separate 15-cm V-Lok sutures with CV-23 needle starting at 11:00 and 2:00 from outside in on the anterior bladder neck to inside out on the anterior urethra. The vesicourethral anastomosis progresses toward the posterior urethra and bladder neck, where the sutures are tied together. BN = bladder neck; EPF = endopelvic fascia; NVB = neurovascular bundle; U = urethra.

factors influencing the recovery of EPIC-CP urinary incontinence and overall scores. Cox regression analysis was performed to analyze factors associated with incontinence at 12 mo after RP.

3. Results

3.1. Study population

Baseline clinical data are presented in Table 1. A total of 140 consecutive RARPs were performed over the study period: 70 S-RARPs and 70 RS-RARPs. Median follow-up was 12.3 versus 46.3 mo for RS-RARP versus S-RARP. There were no significant differences in age, BMI, CCI, PSA, clinical stage, or baseline EPIC-CP scores. Men undergoing RS-RARP versus S-RARP had higher GG (2.6 vs 2.2, $p = 0.042$) and PIRADS (4.3 vs 3.9, $p = 0.043$) scores.

3.2. Outcomes

Table 2 reveals perioperative data. RS-RARP versus S-RARP was associated with lower median EBL (100 vs 250 cc, $p < 0.001$). There were no differences in console time, nerve sparing, length of stay, or complication rates.

Table 1 – Preoperative patient demographics and clinical data.

	RS-RARP (*N* = 70)	S-RARP (*N* = 70)	*p* value
Age (yr), mean ± SD	62.1 ± 6.5	61.9 ± 6.5	0.855
BMI (kg/m^2), mean ± SD	28.4 ± 4.7	27.6 ± 4.3	0.257
Charlson Comorbidity Index, mean ± SD	4.1 ± 1.2	4.0 ± 0.9	0.340
PSA (ng/mL), mean ± SD	7.2 ± 3.2	8.5 ± 6.3	0.131
Gleason group, mean ± SD	2.6 ± 1.2	2.2 ± 1.2	0.042
MRI PIRADS score, mean ± SD	4.3 ± 0.9	3.9 ± 1.2	0.043
Clinical stage, no. (%)			
T1	50 (71.4)	45 (64.3)	0.841
T2	13 (18.6)	17 (24.3)	
T3	7 (10.0)	8 (11.4)	
Baseline EPIC-CP urinary incontinence score, mean ± SD	1.0 ± 1.8	0.7 ± 1.2	0.240
Baseline EPIC-CP sexual function score, mean ± SD	2.9 ± 3.1	3.1 ± 3.6	0.701
Baseline EPIC-CP total score, mean ± SD	8.3 ± 7.0	7.2 ± 7.9	0.429

BMI = body mass index; EPIC-CP = Expanded Prostate Cancer Index Composite for Clinical Practice; MRI = magnetic resonance imaging; PIRADS = Prostate Imaging Reporting and Data System; PSA = prostate-specific antigen; RS-RARP = Retzius-sparing robot-assisted radical prostatectomy; SD = standard deviation; S-RARP = standard robot-assisted radical prostatectomy.

Table 2 – Perioperative data.

	RS-RARP (*N* = 70)	S-RARP (*N* = 70)	*p* value
Console time (min), mean ± SD	130 ± 26.1	128 ± 25.7	0.646
Nerve sparing, no. (%)			
Any NS	59 (84.3)	52 (74.3)	0.146
Complete	34 (48.6)	39 (55.7)	0.401
EBL (ml), median (IQR)	100 (75–200)	250 (100–388)	<0.001
LOS (d), mean ± SD	1.1 ± 0.4	1.7 ± 2.3	0.052
Complication, no. (%)	3 (4.3)	6 (8.6)	0.305

EBL = estimated blood loss; IQR = interquartile range; LOS = length of stay; NS = nerve sparing; RS-RARP = Retzius-sparing robot-assisted radical prostatectomy; SD = standard deviation; S-RARP = standard robot-assisted radical prostatectomy.

Table 3 – Pathologic and oncologic data.

	RS-RARP (*N* = 70)	S-RARP (*N* = 70)	*p* value
Gleason group, mean ± SD	2.6 ± 0.7	2.2 ± 1.2	0.062
Prostate weight (g), mean ± SD	43.7 ± 18.8	47.6 ± 16.0	0.183
Pathologic stage, no. (%)			
T2	47 (67.1)	48 (68.6)	0.842
T3a	14 (20.0)	15 (21.4)	
T3b	9 (12.9)	7 (10.0)	
Lymph node involvement, no. (%)	1 (1.4)	3 (4.3)	0.314
Positive margin, no. (%)	24 (34.3)	21 (30.0)	0.590
Focal	19 (27.1)	15 (21.4)	0.434
Nonfocal	5 (7.1)	6 (8.6)	0.016
Margin location, no. (%)			
Posterior	9 (39.1)	12 (70.6)	0.125
Anterior	12 (52.2)	5 (29.4)	
Apex	6 (26.1)	6 (33.3)	
Biochemical recurrence, no. (%)	9 (12.9)	13 (18.6)	0.357
Time to BCR (d), median (IQR)	78 (58–270)	248 (148–388)	0.193
Adjuvant therapy, no. (%)	13 (18.6)	15 (21.4)	0.675
Pentafecta, no. (%)	35 (50.0)	35 (50.0)	1.000

BCR = biochemical recurrence; IQR = interquartile range; RS-RARP = Retzius-sparing robot-assisted radical prostatectomy; SD = standard deviation; S-RARP = standard robot-assisted radical prostatectomy.

Table 3 demonstrates pathologic outcomes. There were no significant differences in GG, pathologic stage, lymph node positivity, or overall and focal PSMs. However, RS-RARP had fewer nonfocal PSMs (7.1% vs 8.6%, $p = 0.016$). Location of PSMs did not differ significantly, but most PSMs were anterior for RS-RARP (54.2%) versus posterior for S-RARP (70.6%). There was no difference in BCR, rates of adjuvant therapy, or pentafecta outcomes.

Overall current continence, continence at 12-mo follow-up, time to continence, and potency are displayed in Table 4. There were no differences in continence rates when defined as zero pads, although there were higher continence rates for RS-RARP versus S-RARP when defined as zero to one safety pad (95.7% vs 85.7%, $p = 0.042$). For patients with 12-mo follow-up, continence (zero to one pad) at 12 mo remained significantly better for RS-RARP

Table 4 – Continence and potency outcomes.

	RS-RARP (*N* = 70)	S-RARP (*N* = 70)	*p* value
Overall continence at follow-up, no. (%)			
0 pads	47 (67.1)	47 (67.1)	1.000
0–1 safety pad	67 (95.7)	60 (85.7)	0.042
Continence at 12 mo, no. (%) [a]			
0 pads	30 (73.2)	46 (65.7)	0.141
0–1 safety pad	40 (97.6)	57 (81.4)	0.002
Time to continence (d), median (IQR)			
0 pads	59 (17–137)	182 (105–273)	<0.001
0–1 safety pad	49 (10–57)	64 (49–143)	<0.001
Potency, no. (%)	46 (65.7)	44 (62.9)	0.727

IQR = interquartile range; RS-RARP = Retzius-sparing robot-assisted radical prostatectomy; S-RARP = standard robot-assisted radical prostatectomy.

[a] With at least 12-mo follow-up: RS-RARP, *N* = 41; S-RARP, *N* = 70.

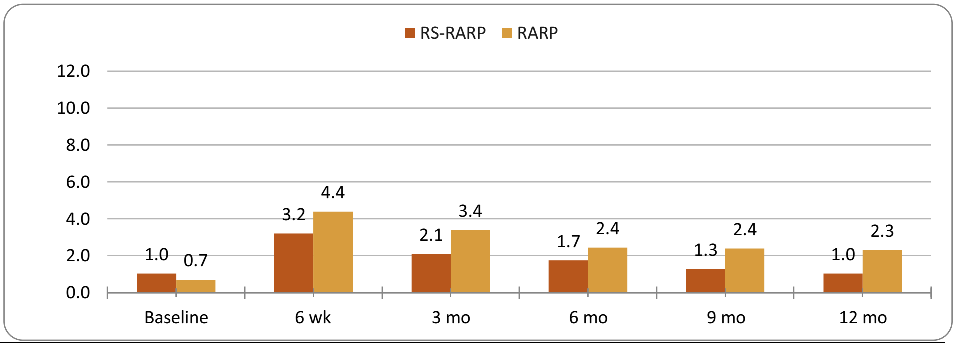
than for S-RARP (97.6% vs 81.4%, $p = 0.002$). RS-RARP versus S-RARP demonstrated earlier median time to continence when defined as zero pads (59 vs 182 d, $p < 0.001$) and zero to one safety pad (49 vs 64 d, $p < 0.001$). There were no significant differences in potency rates.

Tables 5–7 demonstrate EPIC-CP urinary incontinence, sexual, and overall scores over the study period. RS-RARP had significantly improved EPIC-CP urinary incontinence scores at 6 wk and 3, 9, and 12 mo. There were no significant differences in sexual function scores. Total EPIC-CP scores were better for RS-RARP at 9 and 12 mo (7.9 vs 12.1, $p = 0.0018$ and 6.9 vs 10.4, $p = 0.025$, respectively).

Tables 8 and 9 compare baseline versus 12-mo EPIC-CP scores. In men undergoing RS-RARP, urinary incontinence and total EPIC-CP scores returned to baseline, although sexual scores did not (2.9 vs 4.6, $p = 0.046$). In contrast, men undergoing S-RARP had significant differences between baseline and 12-mo urinary incontinence (0.7 vs 2.3, $p < 0.001$), sexual function (3.1 vs 5.3, $p = 0.002$), and total EPIC-CP scores (7.2 vs 10.4, $p = 0.022$).

Table 10 summarizes the results of multivariate logistic regression analysis of predictors of PSM and BCR. PSA (odds ratio [OR] 1.12, 95% confidence interval [CI] 1.02–1.24), nerve sparing (OR 4.90, 95% CI 4.90–1.19), and pT3 disease

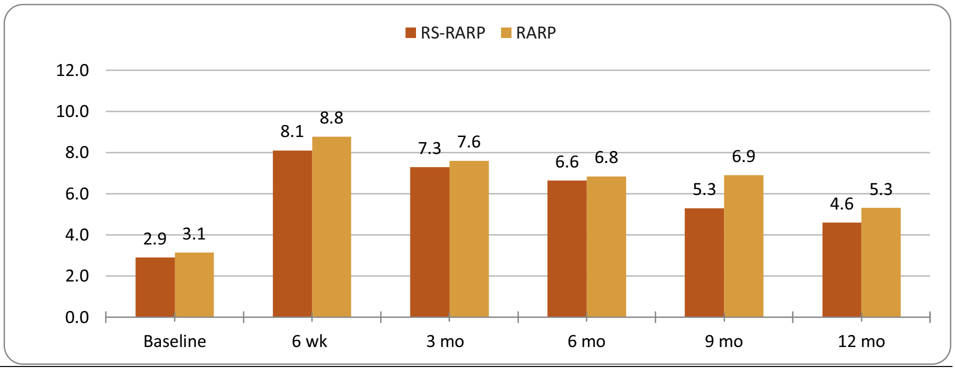
Table 5 – EPIC-CP urinary incontinence scores.



	RS-RARP	S-RARP	*p* value
Baseline, mean ± SD	1.0 ± 1.8	0.7 ± 1.2	0.240
6 wk, mean ± SD	3.2 ± 2.3	4.4 ± 2.9	0.014
3 mo, mean ± SD	2.1 ± 2.1	3.4 ± 2.6	0.008
6 mo, mean ± SD	1.7 ± 1.7	2.4 ± 2.0	0.076
9 mo, mean ± SD	1.3 ± 1.6	2.4 ± 2.5	0.010
12 mo, mean ± SD	1.0 ± 1.2	2.3 ± 2.6	0.033

EPIC-CP = Expanded Prostate Cancer Index Composite for Clinical Practice; RARP = robot-assisted radical prostatectomy; RS-RARP = Retzius-sparing robot-assisted radical prostatectomy; SD = standard deviation; S-RARP = standard robot-assisted radical prostatectomy.

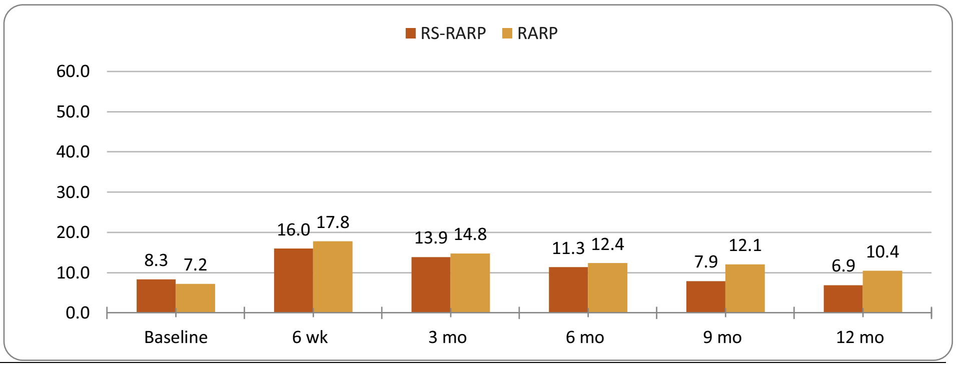
Table 6 – EPIC-CP sexual function scores.



	RS-RARP	S-RARP	*p* value
Baseline, mean ± SD	2.9 ± 3.1	3.1 ± 3.6	0.701
6 wk, mean ± SD	8.1 ± 3.1	8.8 ± 2.7	0.218
3 mo, mean ± SD	7.3 ± 3.6	7.6 ± 3.4	0.653
6 mo, mean ± SD	6.6 ± 3.6	6.8 ± 3.3	0.764
9 mo, mean ± SD	5.3 ± 4.1	6.9 ± 3.0	0.091
12 mo, mean ± SD	4.6 ± 3.4	5.3 ± 2.6	0.417

EPIC-CP = Expanded Prostate Cancer Index Composite for Clinical Practice; RARP = robot-assisted radical prostatectomy; RS-RARP = Retzius-sparing robot-assisted radical prostatectomy; SD = standard deviation; S-RARP = standard robot-assisted radical prostatectomy.

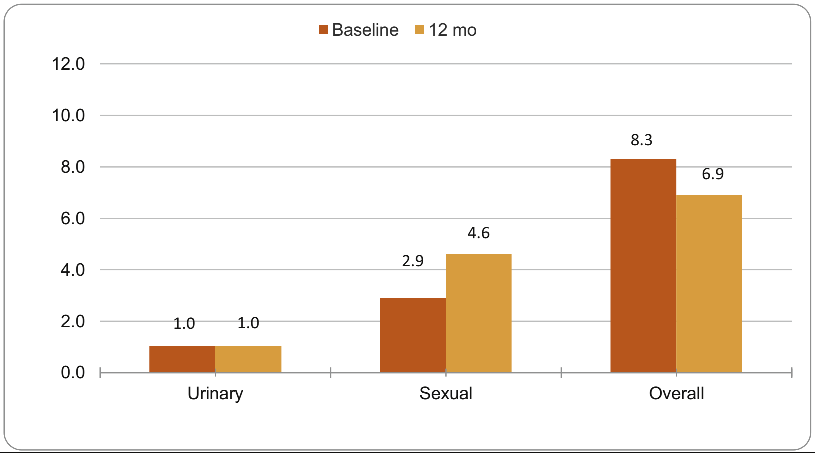
Table 7 – EPIC-CP total QOL scores.



	RS-RARP	S-RARP	*p* value
Baseline, mean ± SD	8.3 ± 7.0	7.2 ± 7.9	0.429
6 wk, mean ± SD	16.0 ± 6.2	17.8 ± 6.6	0.106
3 mo, mean ± SD	13.9 ± 7.4	14.8 ± 6.8	0.540
6 mo, mean ± SD	11.3 ± 6.3	12.4 ± 6.1	0.414
9 mo, mean ± SD	7.9 ± 6.5	12.1 ± 6.5	0.018
12 mo, mean ± SD	6.9 ± 4.8	10.4 ± 6.7	0.025

EPIC-CP = Expanded Prostate Cancer Index Composite for Clinical Practice; QOL = quality of life; RARP = robot-assisted radical prostatectomy; RS-RARP = Retzius-sparing robot-assisted radical prostatectomy; SD = standard deviation; S-RARP = standard robot-assisted radical prostatectomy.

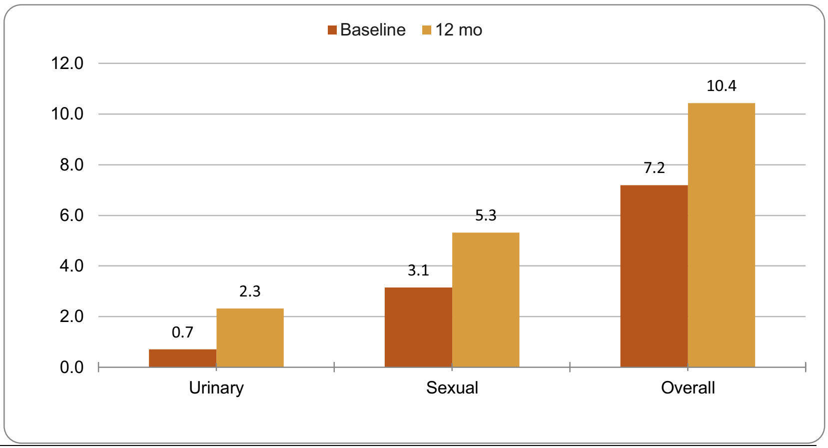
Table 8 – RS-RARP baseline versus 12-mo EPIC-CP scores.



	Baseline	12 mo	*p* value
Urinary, mean ± SD	1.0 ± 1.8	1.0 ± 1.2	0.974
Sexual, mean ± SD	2.9 ± 3.1	4.6 ± 3.4	0.032
Overall, mean ± SD	8.3 ± 7.0	6.9 ± 4.8	0.388

EPIC-CP = Expanded Prostate Cancer Index Composite for Clinical Practice; RS-RARP = Retzius-sparing robot-assisted radical prostatectomy; SD = standard deviation.

Table 9 – S-RARP baseline versus 12-mo EPIC-CP scores.



	Baseline	12 mo	*p* value
Urinary, mean ± SD	0.7 ± 1.2	2.3 ± 2.6	0.000
Sexual, mean ± SD	3.1 ± 3.6	5.3 ± 2.6	0.002
Overall, mean ± SD	7.2 ± 7.9	10.4 ± 6.7	0.022

EPIC-CP = Expanded Prostate Cancer Index Composite for Clinical Practice; SD = standard deviation; S-RARP = standard robot-assisted radical prostatectomy.

Table 10 – Multivariate logistic regression models of positive surgical margin and biochemical recurrence.

Variable	Odds ratio	95% CI		*p* value
Positive surgical margin				
PSA	1.12	1.02	1.24	0.021
RS-RARP vs S-RARP	1.46	0.56	3.79	0.434
Nerve sparing	4.90	1.19	20.09	0.027
EBL	1.00	0.99	1.00	0.153
GG (Ref = 1)				
2	1.35	0.32	5.80	0.685
3	1.26	0.21	7.42	0.801
4	0.24	0.01	4.83	0.349
5	1.59	0.19	13.29	0.667
Stage pT3 vs pT2	5.17	1.70	15.73	0.004
Biochemical recurrence				
PSA	1.07	0.95	1.20	0.301
RS-RARP vs S-RARP	0.58	0.17	1.97	0.380
GG (Ref = 1)				
2	1.23	0.12	12.86	0.863
3	2.71	0.20	36.3	0.452
4	5.47	0.20	151.15	0.316
5	15.68	1.10	223.77	0.042
Perineural invasion	0.72	0.13	3.91	0.701
Positive surgical margin	0.52	0.14	2.03	0.350
Stage pT3 vs pT2	3.76	0.91	15.53	0.067
N+ disease	2.83	0.08	95.65	0.562

CI = confidence interval; EBL = estimated blood loss; GG = Gleason group; PSA = prostate-specific antigen; Ref = reference; RS-RARP = Retzius-sparing robot-assisted radical prostatectomy; S-RARP = standard robot-assisted radical prostatectomy.

Table 11 – Multivariate linear regression models of 12-mo EPIC-CP urinary incontinence score and 12-mo EPIC-CP total score.

Variable	Regression coefficient	Standard error	*p* value
12-mo EPIC-CP urinary incontinence score			
Age	–0.01	0.04	0.740
BMI	–0.07	0.15	0.165
RS-RARP vs S-RARP	–1.06	0.50	0.038
Nerve sparing	–0.14	0.75	0.850
Stage pT3 vs pT2	0.77	0.69	0.268
Preoperative EPIC-CP UI score	0.45	0.16	0.007
12-mo EPIC-CP total score			
Age	0.05	0.11	0.650
BMI	–0.07	0.15	0.624
RS-RARP vs S-RARP	–2.87	1.40	0.044
Nerve sparing	–5.32	2.13	0.015
Stage pT3 vs pT2	0.10	1.98	0.961
Preoperative EPIC-CP total score	0.27	0.09	<0.001

BMI = body mass index; EPIC-CP = Expanded Prostate Cancer Index Composite for Clinical Practice; RS-RARP = Retzius-sparing robot-assisted radical prostatectomy; S-RARP = standard robot-assisted radical prostatectomy; UI = urinary incontinence.

(OR 5.17, 95% CI 1.70–15.73) predicted an increased risk of PSM, while GG5 (OR 15.68, 95% CI 1.10–223.77) was a predictor of BCR. RS-RARP was not significantly associated with PSM or BCR.

Table 11 summarizes the results of multivariate linear regression analysis of the predictors of EPIC-CP urinary incontinence and total scores at 12 mo. RS-RARP (regression coefficient –1.06, $p = 0.038$) was the most significant predictor of improved 12-mo urinary incontinence scores, while higher preoperative urinary incontinence scores (regression coefficient 0.45, $p = 0.007$) were associated with worse 12-mo scores. Both RS-RARP (regression coefficient –2.87, $p = 0.044$) and nerve sparing (regression coefficient –5.32, $p = 0.015$) were associated with improved total EPIC-CP scores at 12 mo, while higher preoperative EPIC-CP scores (regression coefficient 0.27, $p < 0.001$) was associated with worse scores at 12 mo.

Table 12 summarizes Cox-regression analysis for risk of urinary incontinence (zero to one safety pad) at 12 mo, and RS-RARP was significantly associated with a decreased risk of urinary incontinence (hazard ratio 0.18, 95% CI 0.05–0.67).

4. Discussion

The advent of robotic surgery carried the promise of improved outcomes, and studies have demonstrated that

Table 12 – Cox regression analysis of risk factors for incontinence at 12 mo.

Variable	Hazard ratio	95% CI		*p* value
Age	1.05	0.95	1.16	0.292
BMI	1.09	0.97	1.21	0.139
Baseline EPIC-CP UI score	1.24	0.91	1.69	0.170
Nerve sparing	0.69	0.23	2.04	0.498
RS-RARP vs S-RARP	0.18	0.05	0.67	0.010

BMI = body mass index; CI = confidence interval; EPIC-CP = Expanded Prostate Cancer Index Composite for Clinical Practice; RS-RARP = Retzius-sparing robot-assisted radical prostatectomy; S-RARP = standard robot-assisted radical prostatectomy; UI = urinary incontinence.

S-RARP results in improved continence compared with open prostatectomy [16]. Despite these findings, impaired QOL related to poor postoperative urinary and sexual function persists, with urinary dysfunction being one of the most bothersome complications and ultimately impacting overall satisfaction [1,17]. Despite claims to the contrary, incontinence can still be a significant bother to patients following robotic prostatectomy and is likely underreported [1].

S-RARP modifications have been proposed to improve continence. The periurethral suspension stitch led to earlier return to continence [17]. BN preservation may shorten time to continence, with some studies showing improved 12-mo continence [18,19]. Other techniques include preservation of the puboprostatic ligaments, nerve sparing, pubovesical complex preservation, urethral length preservation, as well as anterior and posterior reconstructive strategies, all in an attempt to maintain or restore as much normal pelvic anatomy as possible [20].

In 2010, Galfano et al [3] described Retzius-sparing prostatectomy, preserving the aforementioned structures without reconstruction. This showed earlier return to continence [3,4,21,22], lending credence to the theory that structures contained within the anterior pelvis play an important role in urinary continence. However, initial series were associated with increased PSMs early in the learning curve, leading to concerns over oncologic efficacy. In the present study, we sought to replicate improved urinary function outcome, both short and long term, while maintaining oncologic efficacy.

Our study has several important findings. First, our data revealed significantly faster return to continence following RS-RARP versus S-RARP in addition to improved urinary function, which persisted at 12 mo following surgery. These differences are not only statistically significant, but also clinically significant as the minimally important difference for the EPIC-CP urinary incontinence is 1.0 [23], which is eclipsed by RS-RARP versus S-RARP at 6 wk and 3, 9, and 12 mo. Additionally, when defined as zero to one safety pad, RS-RARP urinary continence rates were significantly improved compared with S-RARP urinary continence rates (95.7% vs 85.7%), and RS-RARP was strongly associated with a decreased risk of incontinence at 12 mo in regression analysis. This is a novel finding because while others have shown early return to continence, long-term differences in urinary function have been lacking [21,22,24]. Only a meta-analysis by Checcucci et al [5] demonstrated statistically significant and persistently improved continence at 1, 3, 6, and 12 mo. Additionally, prior studies have defined continence as a binary outcome rather than utilizing overall QOL scores such as EPIC-CP in the current study. Our study is the first single-surgeon series to demonstrate that durable improvement in continence and overall urinary function scores persist beyond 6 mo [4] and, in fact, likely persist beyond 12 mo.

Second, there were no differences in PSMs or BCRs between groups, and RS-RARP had fewer nonfocal PSMs. Several studies have demonstrated an increase in PSMs with RS-RARP [5], which are often located anteriorly [5,25]. Increased PSMs may be attributed to the expected learning curve of a new technique, as was seen with early laparoscopic RP and S-RARP series [5,26,27]. More recent studies support fewer PSMs with more experience, as Lee et al [4] found no difference in PSMs in a large series of S-RARP versus RS-RARP. Our results similarly validate the oncologic efficacy of RS-RARP. Additionally, with increasing utilization of preoperative MRI, surgeons may be able to select between S-RARP and RS-RARP as an appropriate surgical approach if they are concerned with anterior versus posterior lesions.

Third, overall QOL was significantly better in men undergoing RS-RARP than in those undergoing S-RARP. This is evident when comparing baseline versus 12-mo EPIC-CP scores, as both urinary and overall QOL scores returned to baseline following RS-RARP. Comparatively, all men undergoing S-RARP continued to have negative QOL impact at 12 mo compared with baseline. To our knowledge, this is the first study to suggest an improvement in overall QOL with RS-RARP.

Lastly, our study did not demonstrate any significant difference in sexual function, which is consistent with prior RS-RARP series. While prior studies have suggested that preservation of pudendal arteries, DVC, and endopelvic fascia may improve sexual function [28–30], we have not seen this to translate into consistently improved sexual function outcomes in our initial RS-RARP series. However, further study and collaboration with other surgeons, as well longer follow-up, may be needed to show improvement in sexual function, which can be seen 2–3 yr following surgery [31].

Limitations of these data include a lack of randomization. However, data were prospectively collected, and all surgeries were performed by the same surgeon. Additionally, S-RARP patients underwent surgery later in the S-RARP learning curve compared to RS-RARP patients, who underwent surgery early in the RS-RARP learning curve. These data would theoretically skew positive outcomes toward S-RARP, which was not seen. Furthermore, this provides a “real-world” scenario of outcomes that a surgeon can expect when transitioning from S-RARP to RS-RARP. Second, there was unequal follow-up between groups; however, the significantly improved continence with RS-RARP at 12 mo is striking despite fewer patients attaining 12-mo follow-up. Third, this is a single-surgeon series, and differences in technique may not be generalizable toward the community. However, RS-RARP has continually shown improved continence outcomes in other series. Regardless, collaborative studies between surgeons are necessary in order to compensate for possible differences between individual surgeon techniques. Finally, longer-term follow-up for RS-RARP patients is needed to ensure no significant compromise in long-term oncologic efficacy. However, given the lack of significant difference in positive margin status and a mean time to BCR of $<$12 mo in both groups, it is unlikely that BCR rates will differ significantly.

5. Conclusions

To our knowledge, this is the first single-surgeon series to report durable improvement in urinary function as well as overall QOL at 12 mo for RS-RARP versus S-RARP. Notably, these outcomes were achieved without compromising oncologic outcomes and with superior rates of nonfocal margins.

Author contributions: Keith J. Kowalczyk 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: Egan, Marhamati, Carvalho, Kowalczyk.
Acquisition of data: Carvalho, O'Neill, Lee, Kowalczyk.
Analysis and interpretation of data: Egan, Marhamati, Kowalczyk.
Drafting of the manuscript: Egan, Marhamati, Kowalczyk.
Critical revision of the manuscript for important intellectual content: Carvalho, Davis, Lynch, Hankins, Hu.
Statistical analysis: Hu, Kowalczyk.
Obtaining funding: Lynch, Kowalczyk.
Administrative, technical, or material support: Lynch, Hankins, Kowalczyk.
Supervision: Kowalczyk.
Other: None.

Financial disclosures: Keith J. Kowalczyk certifies that all conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript (eg, employment/affiliation, grants or funding, consultancies, honoraria, stock ownership or options, expert testimony, royalties, or patents filed, received, or pending), are the following: None.

Funding/Support and role of the sponsor: Jim Hu is supported by The Frederick J. and Theresa Dow Wallace Fund of the New York Community Trust.

Acknowledgments: We are grateful to Dr. Antonio Galfano and Dr. Kevin Rice for their critical review of our surgical technique during this case series. Medical illustrations were by David Klemm, Georgetown University Medical Center, Washington, DC, USA.

Appendix A. Supplementary data

The Surgery in Motion video accompanying this article can be found in the online version at doi: https://doi.org/10.1016/j.eururo.2020.05.010 and via www.europeanurology.com.

References

[1] Hoffman KE, Penson DF, Zhao Z, et al. Patient-reported outcomes through 5 years for active surveillance, surgery, brachytherapy, or external beam radiation with or without androgen deprivation therapy for localized prostate cancer. JAMA 2020;323:149–63.
[2] Holt JD, Gerayli F. Prostate cancer screening. Prim Care 2019;46:257–63.
[3] Galfano A, Ascione A, Grimaldi S, Petralia G, Strada E, Bocciardi AM. A new anatomic approach for robot-assisted laparoscopic prostatectomy: a feasibility study for completely intrafascial surgery. Eur Urol 2010;58:457–61.
[4] Lee J, Kim HY, Goh HJ, et al. Retzius-sparing robot-assisted radical prostatectomy conveys early regain of continence over conventional robot-assisted radical prostatectomy: a propensity matched analysis of 1,863 patients. J Urol 2020;203:137–44.
[5] Checcucci E, Veccia A, Fiori C, et al. Retzius-sparing robot-assisted radical prostatectomy vs the standard approach: a systematic review and analysis of comparative outcomes. BJU Int 2020;125:8–16.
[6] Gragg P, Sellers CL. Twitter. Law Libr J 2010;102:325–30.
[7] Olivero A, Galfano A, Secco S, et al. Retzius-sparing radical prostatectomy for surgeons in the learning curve: a propensity score-matching analysis. Eur Urol Open Sci 2019;18:e3289.
[8] Kowalczyk KJ, Huang AC, Hevelone ND, et al. Effect of minimizing tension during robotic-assisted laparoscopic radical prostatectomy on urinary function recovery. World J Urol 2013;31:515–21.
[9] Alemozaffar M, Duclos A, Hevelone ND, et al. Technical refinement and learning curve for attenuating neurapraxia during robotic-assisted radical prostatectomy to improve sexual function. Eur Urol 2012;61:1222–8.
[10] Kowalczyk KJ, Huang AC, Hevelone ND, et al. Stepwise approach for nerve sparing without countertraction during robot-assisted radical prostatectomy: technique and outcomes. Eur Urol 2011;60:536–47.
[11] Freire MP, Weinberg AC, Lei Y, et al. Anatomic bladder neck preservation during robotic-assisted laparoscopic radical prostatectomy: description of technique and outcomes. Eur Urol 2009;56:972–80.
[12] Galfano A, Panarello D, Secco S, et al. Does prostate volume have an impact on the functional and oncological results of Retzius-sparing robot-assisted radical prostatectomy? Minerva Urol Nefrol 2018;70:408–13.
[13] Galfano A, Secco S, Panarello D, et al. Pain and discomfort after Retzius-sparing robot-assisted radical prostatectomy: a comparative study between suprapubic cystostomy and urethral catheter as urinary drainage. Minerva Urol Nefrol 2019;71:381–5.
[14] Wagner Aa, Cheng Pj, Carneiro A, et al. Clinical use of Expanded Prostate Cancer Index Composite for Clinical Practice to assess patient reported prostate cancer quality of life following robot-assisted radical prostatectomy. J Urol 2017;197:109–14.
[15] Patel VR, Sivaraman A, Coelho RF, et al. Pentafecta: a new concept for reporting outcomes of robot-assisted laparoscopic radical prostatectomy. Eur Urol 2011;59:702–7.
[16] Ficarra V, Novara G, Rosen RC, et al. Systematic review and meta-analysis of studies reporting urinary continence recovery after robot-assisted radical prostatectomy. Eur Urol 2012;62:405–17.
[17] Patel VR, Coelho RF, Palmer KJ, Rocco B. Periurethral suspension stitch during robot-assisted laparoscopic radical prostatectomy: description of the technique and continence outcomes. Eur Urol 2009;56:472–8.
[18] Selli C, De Antoni P, Moro U, Macchiarella A, Giannarini G, Crisci A. Role of bladder neck preservation in urinary continence following

radical retropubic prostatectomy. Scand J Urol Nephrol 2004;38: 32–7.

[19] Ma X, Tang K, Yang C, et al. Bladder neck preservation improves time to continence after radical prostatectomy: a systematic review and meta-analysis. Oncotarget 2016;7:67463–75.

[20] Kojima Y, Takahashi N, Haga N, et al. Urinary incontinence after robot-assisted radical prostatectomy: pathophysiology and intraoperative techniques to improve surgical outcome. Int J Urol 2013;20:1052–63.

[21] Chang LW, Hung SC, Hu JC, Chiu KY. Retzius-sparing robotic-assisted radical prostatectomy associated with less bladder neck descent and better early continence outcome. Anticancer Res 2018;38:345–51.

[22] Menon M, Dalela D, Jamil M, et al. Functional recovery, oncologic outcomes and postoperative complications after robot-assisted radical prostatectomy: an evidence-based analysis comparing the Retzius sparing and standard approaches. J Urol 2018;199:1210–7.

[23] Chipman JJ, Sanda MG, Dunn RL, et al. Measuring and predicting prostate cancer related quality of life changes using EPIC for clinical practice. J Urol 2014;191:638–45.

[24] Dalela D, Jeong W, Prasad MA, et al. A pragmatic randomized controlled trial examining the impact of the Retzius-sparing approach on early urinary continence recovery after robot-assisted radical prostatectomy. Eur Urol 2017;72:677–85.

[25] Lim SK, Kim KH, Shin TY, et al. Retzius-sparing robot-assisted laparoscopic radical prostatectomy: combining the best of retropubic and perineal approaches. BJU Int 2014;114:236–44.

[26] Katz R, Salomon L, Hoznek A, De La Taille A, Antiphon P, et al. Positive surgical margins in laparoscopic radical prostatectomy: the impact of apical dissection, bladder neck remodeling and nerve preservation. J Urol 2003;169:2049–52.

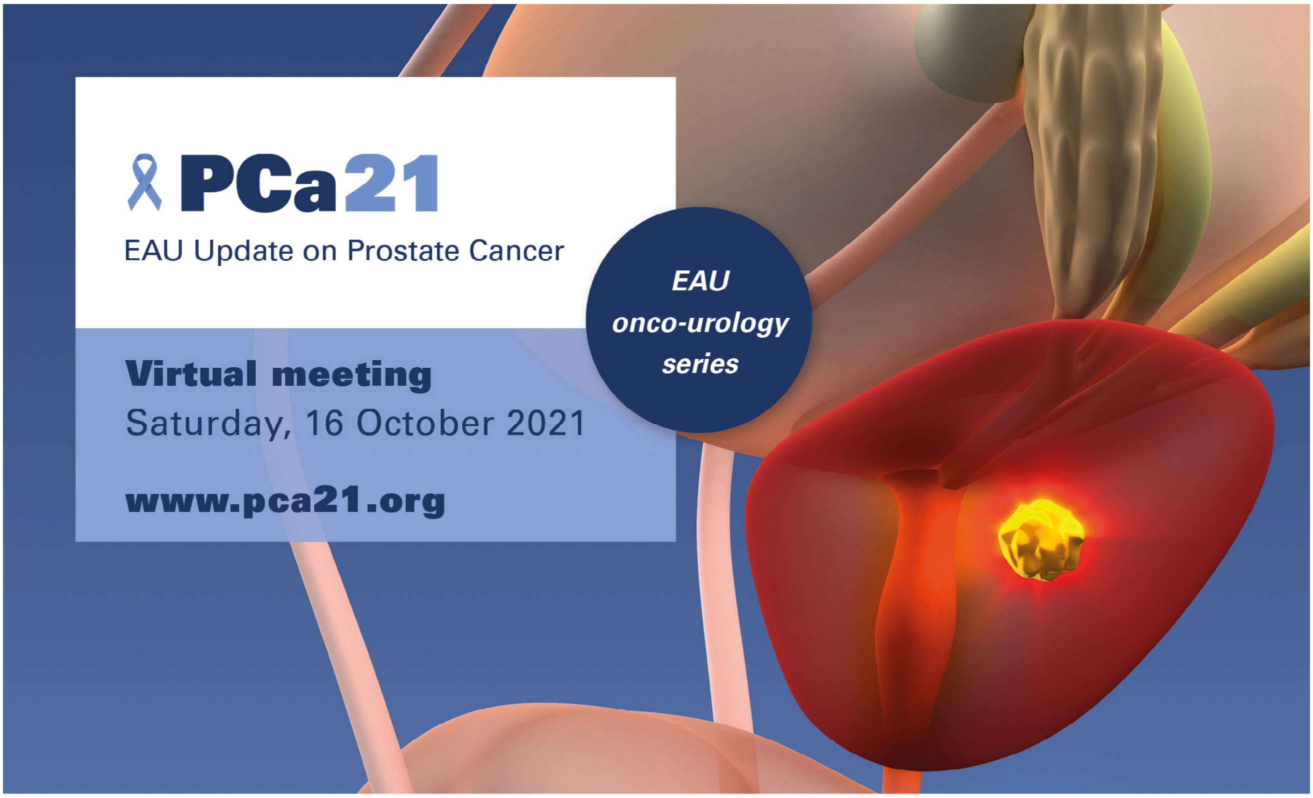
[27] Williams SB, Chen MH, D'Amico AV, et al. Radical retropubic prostatectomy and robotic-assisted laparoscopic prostatectomy: likelihood of positive surgical margin(s). Urology 2010;76:1097–101.

[28] Secin FP, Touijer K, Mulhall J, Guillonneau B. Anatomy and preservation of accessory pudendal arteries in laparoscopic radical prostatectomy. Eur Urol 2007;51:1229–35.

[29] de Carvalho PA, Barbosa JABA, Guglielmetti GB, et al. Retrograde release of the neurovascular bundle with preservation of dorsal venous complex during robot-assisted radical prostatectomy: optimizing functional outcomes. Eur Urol 2020;77:628–35.

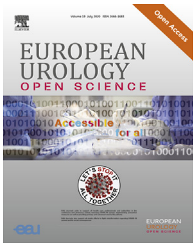
[30] Kaul S, Bhandari A, Hemal A, Savera A, Shrivastava A, Menon M. Robotic radical prostatectomy with preservation of the prostatic fascia: a feasibility study. Urology 2005;66:1261–5.

[31] Rabbani F, Schiff J, Piecuch M, et al. Time course of recovery of erectile function after radical retropubic prostatectomy: does anyone recover after 2 years? J Sex Med 2010;7:3984–90.



EUROPEAN UROLOGY OPEN SCIENCE 22 (2020) 17–22

available at www.sciencedirect.com
journal homepage: www.eu-openscience.europeanurology.com



European Association of Urology

Prostate Cancer

Impact of Retzius-sparing Versus Standard Robotic-assisted Radical Prostatectomy on Penile Shortening, Peyronie's Disease, and Inguinal Hernia Sequelae

Keith J. Kowalczyk [a,*], *Meghan Davis* [a], *John O'Neill* [a], *Harry Lee* [a], *Joanna Orzel* [a], *Rachel S. Rubin* [a,b], *Jim C. Hu* [c]

[a] *Department of Urology, MedStar Georgetown University Hospital, Georgetown University Medical Center, Lombardi Cancer Center, Washington, DC, USA;* [b] *IntimMedicine Specialists, Washington, DC, USA;* [c] *Department of Urology, Weill Cornell Medicine, New York, NY, USA*

Article info

Article history:
Accepted September 25, 2020

Associate Editor:
Guillaume Ploussard

Keywords:
Robotic-assisted surgery
Retzius-sparing prostatectomy
Sexual function
Peyronie's disease
Inguinal hernia

Abstract

Background: Retzius-sparing robotic-assisted radical prostatectomy (RS-RARP) has improved urinary function compared with standard robotic-assisted radical prostatectomy (S-RARP). As RS-RARP spares the dorsal vascular complex, pelvic fascia, and anterior abdominal fascia, it may also lower the incidence of "neglected" postprostatectomy sequelae such as penile shortening, Peyronie's disease, and inguinal hernias.
Objective: To determine whether there are patient-perceived differences in penile shortening, Peyronie's disease, and inguinal hernia rates among men undergoing RS-RARP versus S-RARP.
Design, setting, and participants: Researchers uninvolved in clinical care and blinded to surgical approach surveyed 60 RS-RARP versus 57 S-RARP men with validated patient-reported items to assess penile shortening, Peyronie's disease, and inguinal hernia sequelae following surgery.
Intervention: RS-RARP versus S-RARP.
Outcome measurements and statistical analysis: Univariate differences between the two cohorts were analyzed using Student t test. Logistic regression was used to analyze variables associated with postoperative penile shortening. Cox proportional hazards models were used to assess the risk of developing Peyronie's disease and inguinal hernia postoperatively.
Results and limitations: RS-RARP was associated with less patient-reported penile shortening (41.7% vs 64.9%, $p = 0.012$), Peyronie's disease (0% vs 8.7%, $p = 0.020$), and inguinal hernia (0.0% vs 13.0%, $p = 0.004$). In adjusted analyses, RS-RARP (odds ratio [OR] 0.24, 95% confidence interval [CI] 0.09–0.63, $p = 0.004$) was associated with lower odds of penile shortening, while a higher body mass index was associated with increased odds of penile shortening (OR 1.13, 95% CI 1.01–1.26, $p = 0.037$). RS-RARP was not associated with a decreased risk of Peyronie's disease on Cox

---

[*] Corresponding author. Department of Urology, MedStar Georgetown University Hospital, Georgetown University Medical Center, Lombardi Cancer Center, Washington, DC, USA.
Tel.: +1-202-444-4922, Fax: +1-877-625-1478.
E-mail address: keith.kowalczyk@medstar.net (K.J. Kowalczyk).

http://dx.doi.org/10.1016/j.euros.2020.09.004

proportion hazard model; however, these models are limited due to a limited number of events in our cohort. Limitations include retrospective design, patient-reported outcomes, and small cohorts.

Conclusions: RS-RARP is associated with less patient-reported penile shortening and may decrease the risk of Peyronie's disease and postoperative inguinal hernia development. These new findings add to research, showing improved urinary continence and quality of life following RS-RARP; however, a prospective study is needed to validate these findings.

Patient summary: Retzius-sparing robotic-assisted radical prostatectomy (RS-RARP) is an evolving surgical technique for prostate cancer treatment, which has shown improved postoperative urinary control compared with the standard technique, likely due to preservation of natural pelvic anatomy. Our findings suggest that the preservation of normal pelvic anatomy during RS-RARP may also reduce the risk of postprostatectomy penile shortening, Peyronie's disease, and inguinal hernia.

1. Introduction

Most research on robotic-assisted radical prostatectomy (RARP) adverse events beyond the perioperative period focuses on the recovery of urinary and sexual function. While these are significant life-altering patient-centered outcomes, other "hidden" risks, including adverse events such as penile shortening, Peyronie's disease, and inguinal hernia impact survivorship significantly. A 3-mo post–radical prostatectomy (RP) survey of men at a high-volume academic referral center indicated that no patient remembered counseling about the risks of penile shortening and Peyronie's disease [1].

Standard RARP (S-RARP) and retropubic RP includes dissecting the bladder from the anterior abdominal wall, followed by division of the dorsal vascular complex (Fig. 1A). Physiologically, division of arterial tributaries to the penis is thought to result in penile shortening [2]. Similarly, preserving accessory pudendal arteries during RP improves recovery of erectile function [3]. Peyronie's disease, an inflammatory process leading to penile deformity (precluding intercourse, in extreme cases), has a much higher incidence after RP (15.9%) than the general population [4]. Finally, adverse events such as inguinal hernia occur in 7.5–13.7% of men after RP [5].

In 2010, Galfano et al [6] described Retzius-sparing RARP (RS-RARP), a technique that preserves pelvic fascial anatomy as well as the dorsal vascular complex (Fig. 1B) in contrast to S-RARP. In addition, by virtue of the entire RS-RARP dissection being below the endopelvic fascia, accessory pudendal arteries are completely preserved. Finally, there is no separation of the bladder from the anterior abdominal wall during RS-RARP. The transversalis fascia and other supporting abdominal fasciae are left intact, thus likely preventing inguinal hernia sequelae.

Our RS-RARP comparative series is the third study, published from a US medical center, to demonstrate an 80% reduction in the risk of urinary incontinence at 12 mo and is also the first to demonstrate improved overall patient quality of life following surgery [7]. Given our finding of improved overall quality of life, we sought to determine whether RS-RARP has additional anatomic advantages through a patient survey of neglected and potentially hidden RP adverse events that impact survivorship negatively.

2. Patients and methods

Our study design and surgical technique have been described previously [7]: 140 consecutive RARPs were performed by a single surgeon (K.J.K.), with the first 70 undergoing S-RARP and the last 70 undergoing RS-RARP following the surgeon's change in approach. For the present study, outcome assessors not involved in clinical care and blinded to surgical approach surveyed 60 RS-RARP versus 57 S-RARP procedures using validated items for penile shortening and Peyronie's disease from prior studies [2,8]. The item for penile shortening was developed from in-depth interviews with men undergoing RP, and face validity was assured by having an investigator accompany the patient to ensure accurate interpretation while they completed the items [2]. The item queries: "Is your penile length subjectively shorter compared to before prostatectomy (yes vs no)?" The item for Peyronie's disease was validated through blinded clinical examination with 100% sensitivity and 99.4% specificity, and asks the following question: "Have you noticed any new penile curvature or deformity in a flaccid or erect state following prostatectomy?" [8]. Finally, we conducted a medical history and asked: "Have you been diagnosed or treated for an inguinal hernia following prostatectomy?"

The mean follow-up was 14 mo for RS-RARP and 55 mo for S-RARP. Baseline preoperative characteristics (age and baseline Expanded Prostate Cancer Index for Clinical Practice [EPIC-CP] score), perioperative variables (nerve-sparing procedure, estimated blood loss, and console time), postoperative outcomes (complications, and need for adjuvant radiation or hormonal therapy), as well as patient-reported outcomes were compared utilizing Student t test, with $p < 0.05$ considered significant. A nerve-sparing procedure was defined as bilateral intrafascial nerve sparing, combined interfascial and intrafascial nerve sparing, and bilateral interfascial nerve sparing in any patient. Non–nerve sparing was defined as unilateral nerve sparing or bilateral extrafascial nerve sparing.

Multivariable logistic regression was utilized to analyze variables associated with penile shortening following surgery. Cox proportional hazards models were utilized to assess association of RS-RARP with

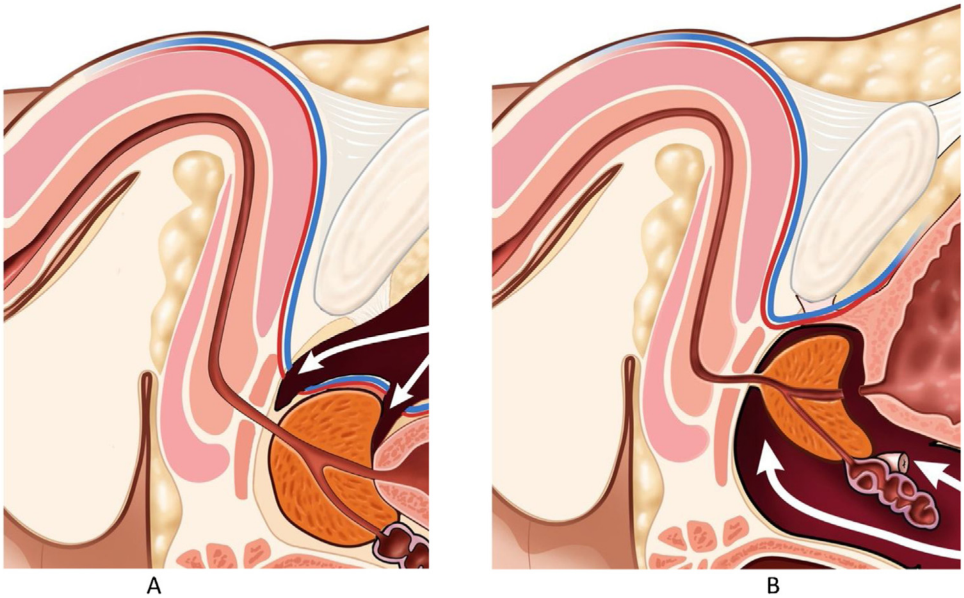


Fig. 1 – Sagittal pelvic view during (A) standard RARP and (B) Retzius-sparing RARP. Disruption of the dorsal vascular complex at both the bladder neck and the prostate apex during standard RARP contributes to penile shortening and Peyronie's disease. The dorsal vascular complex is left intact during Retzius-sparing RARP (Fig. 1B). RARP = robotic-assisted radical prostatectomy.

postoperative Peyronie's disease and inguinal hernia. Variables for the model were included if $p < 0.2$ on univariate analysis.

3. Results

Table 1 summarizes patient baseline characteristics and perioperative outcomes. RS-RARP had significantly more men with higher Gleason grade groups ($p = 0.038$) and lower mean estimated blood loss (187 vs 325 ml, $p < 0.001$) than S-RARP.

Table 1 – Baseline characteristics and perioperative results of RS-RARP and S-RARP cohorts

	RS-RARP ($N = 60$)	S-RARP ($N = 57$)	p value
Age (yr), mean	61.4	61.1	0.811
BMI (kg/m^2), mean	29.5	27.9	0.066
Charlson Comorbidity Index, mean	4.0	3.9	0.510
Preoperative PSA, mean	7.9	8.8	0.470
Preoperative Gleason group, n (%)			
1	9 (15.0)	19 (33.3)	0.038
2	21 (35.0)	22 (38.6)	
3	15 (25.0)	10 (17.5)	
4	13 (21.7)	3 (5.3)	
5	2 (3.3)	3 (5.3)	
Preop potency, n (%)	60 (100.0)	60 (100.0)	1.000
Preop EPIC-CP sexual function score, mean	3.0	2.5	0.391
Any nerve sparing, n (%)	51 (85.0)	48 (84.2)	0.907
EBL (ml), mean	187	325	0.000
Console time (min), mean	128	128	1.000
Postoperative complication, n (%)	4 (6.8)	7 (12.3)	0.316

BMI = body mass index; EBL = estimated blood loss; EPIC-CP = Expanded Prostate Cancer Index for Clinical Practice; Preop = preoperative; PSA = prostate-specific antigen; RS-RARP = Retzius-sparing robotic-assisted radical prostatectomy; S-RARP = standard robotic-assisted radical prostatectomy.

RS-RARP versus S-RARP (Table 2) was significantly associated with less penile shortening (41.7% vs 66.7%, $p = 0.012$), Peyronie's disease (0% vs 8.7%, $p = 0.020$), and fewer inguinal hernias (0.0% vs 12.3%, $p = 0.006$).

In adjusted analyses (Table 3), RS-RARP (odds ratio [OR] 0.24, 95% confidence interval [CI] 0.09–0.63, $p = 0.004$) was independently associated with a lower risk of postoperative penile shortening. Conversely, a higher body mass index (BMI) was associated with a higher risk of postoperative penile shortening (OR 1.13, 95% CI 1.01–1.26, $p = 0.037$).

There were no significant variables related to the risk of developing postoperative Peyronie's disease or inguinal hernia (Tables 4 and 5).

4. Discussion

Studies demonstrate that RS-RARP leads to early recovery of urinary function [6,9]. However, there are a few studies that have follow-up at 1 yr and beyond, and our series was the first to demonstrate that urinary continence advantages of RS-RARP persists at 12 mo utilizing the EPIC-CP score, a validated patient-reported quality of life questionnaire [7]. Moreover, we hypothesized that anatomic differences

Table 2 – Outcomes of answers to survey questions regarding penile shortening, deformity, and inguinal hernia development

	RS-RARP ($N = 60$)	S-RARP ($N = 57$)	p value
Penile shortening	25 (41.7)	37 (66.7)	0.012
Peyronie's disease	0 (0.0)	5 (8.7)	0.020
Inguinal hernia	0 (0.0)	7 (12.3)	0.006

RS-RARP = Retzius-sparing robotic-assisted radical prostatectomy; S-RARP = standard robotic-assisted radical prostatectomy.

Table 3 – Multivariate logistic regression determining factors influencing postoperative penile shortening

Variable	Odds ratio	95% Confidence interval		*p* value
Age	0.99	0.92	1.07	0.926
BMI	1.13	1.01	1.26	0.037
RS-RARP vs S-RARP	0.24	0.09	0.63	0.004
Nerve sparing	0.26	0.06	1.12	0.071
Prostate weight	1.01	0.99	1.04	0.426
Preoperative EPIC sexual domain score	1.01	0.86	1.18	0.922
Postoperative potency	0.94	0.55	1.62	0.835

BMI = body mass index; EPIC = Expanded Prostate Cancer Index; RS-RARP = Retzius-sparing robotic-assisted radical prostatectomy; S-RARP = standard robotic-assisted radical prostatectomy.

Table 4 – Cox proportional hazards model to assess the risk of postoperative Peyronie's disease

Variable	Hazard ratio	95% Confidence interval		*p* value
Time from surgery	0.99	0.98	1.01	0.626
RS-RARP vs S-RARP	0.98	0.47	2.03	0.947
Nerve sparing	0.95	0.51	1.74	0.856
Preoperative EPIC sexual domain score	0.99	0.93	1.06	0.823
Postoperative potency	1.04	0.81	1.32	0.780

EPIC = Expanded Prostate Cancer Index; RS-RARP = Retzius-sparing robotic-assisted radical prostatectomy; S-RARP = standard robotic-assisted radical prostatectomy.

in surgical approach may confer additional benefits for RS-RARP. The "hidden" post-RP complications such as penile shortening, Peyronie's disease, and inguinal hernia may be long-term complications that may also mitigated by RS-RARP. Our study has several important findings. First, RS-RARP was associated with fewer patient-reported adverse events such as penile shortening. Up to 55% of men report penile shortening after RP [2], which is somewhat lower than our finding of 66.7% of patients. Gontero et al [10] studied postprostatectomy penile shortening, noting that the most severe penile shortening, measured by stretched penile length, occurred at the time of catheter removal, which remained significant over 1 yr postoperatively, with a mean decrease of 1.3 and 2.3 cm in flaccid and stretched penile length, respectively. This causes bother, worsens quality of life, and lowers self-esteem [2]. While differences in penile length and circumference have been noted as a sequela of RP, the precise etiology remains unclear [11]. In the study by Gontero et al [10], nerve-sparing technique and recovery of erectile function have been associated with preservation of penile length. However, all patients underwent retropubic RP with division of the dorsal vascular complex. Therefore, the effect of dorsal vascular complex preservation remains unknown. Lei et al [12] were the first to describe the presence of two arterioles that are severed during the division of the dorsal vascular complex with S-RARP. These arterioles supply the corpora cavernosum, and vascular preservation may attenuate penile shortening.

Data increasingly show the role of the pelvic floor in erectile health [13]. Another possible contributing factor for penile shortening during S-RARP may be the change of the structural support from dropping the bladder away from the anterior abdominal wall and entering the endopelvic fascia. Preservation of the pelvic fascial support with RS-RARP may help preserve the penile length lost in comparison with conventional RP. Many have posited that the loss of urethral length leads to penile shortening within the 1st year following surgery; however, changes in urethral length after RP normalized 1 yr following surgery. Kadono et al [14] measured membranous urethral length by magnetic resonance imaging, finding shortening 10 d after RP but reversal of this shortening 12 mo after RP. RS-RARP avoids arterial disruption and preserves the fascial support of the bladder and the membranous urethra, thus potentially mitigating the loss of membranous urethral seen following RP.

Second, no RS-RARP patient experienced Peyronie's disease, while 8.3% of S-RARP patients experienced Peyronie's disease, which is both statistically and clinically significant. Peyronie's disease has been reported in up to 15.9% of men following prostatectomy [4]. The pathophysiology of postprostatectomy Peyronie's disease remains unclear, although Peyronie's disease may result from microvascular injury, resulting in fibrin deposition and trapping within the tunica albuginea that surrounds the corpora, which causes pathological fibrosis and plaque formation [15].Preservation of the arterioles in the dorsal vascular complex may prevent corporal injury leading to Peyronie's disease. This is supported by Iacono et al [16], who found significantly increased collagen deposition on post-RP cavernosal biopsy with a corresponding decrease in elastic and smooth muscle fibers. They postulated that both denervation and ischemia resulting from the disruption of nervous and arterial supply to the penis led to these histological changes, which may explain post-RP penile shortening as well as Peyronie's disease. While RS-RARP was not associated with a decreased risk of postoperative Peyronie's disease in our Cox proportional hazards model, given the overall rarity of events in our cohort, these models may not be robust enough to provide any significance.

Table 5 – Cox proportional hazards model to assess the risk of postoperative inguinal hernia

Variable	Hazard ratio	95% Confidence interval		*p* value
Time from surgery	0.99	0.99	1.01	0.858
Age	1.01	0.98	1.04	0.643
RS-RARP vs S-RARP	1.06	0.56	2.01	0.866
Console time	0.99	0.99	1.01	0.714
Estimated blood loss	1.00	0.99	1.00	0.679

RS-RARP = Retzius-sparing robotic-assisted radical prostatectomy; S-RARP = standard robotic-assisted radical prostatectomy.

Third, on adjusted analysis we found that nerve sparing and postoperative potency were not associated with penile length preservation. Similarly, Savoie et al [11] performed a prospective study on post-RP penile length and also found that potency did not predict shortening. The association of nerve sparing with less penile shortening supports the theory that neurogenic injury can lead to postoperative collagen deposition and erectile dysfunction [16]; however, this was not significant in our group, although it approached significance. Future studies with more power are needed to determine whether nerve-sparing procedures affect postoperative penile shortening. We also found that men with a higher BMI were more likely to experience shortening. While obese men have been found to have worse potency outcomes following RP [17], to our knowledge, the finding of increased penile shortening in obese men is a novel finding. Additionally, in contrast to Kadono et al [14], we did not find prostate weight to have a significant association with the postoperative loss of penile length.

Finally, no RS-RARP patients developed adverse events such as inguinal hernia compared with 14.6% of S-RARP patients. The incidence of post-RP adverse events such as inguinal hernia ranges from 7.5% to 13.7%. These are usually indirect hernias and manifest within 2–3 yr following surgery [5]. Disruption of Hesselbach's triangle when releasing the bladder from the anterior abdominal wall and violating the transversalis fascia, as well as possible disruption of the deep inguinal ring, is thought to be a contributing factor [18]. During RS-RARP, the anterior abdominal wall is left undisturbed, thus avoiding these risk factors for hernia development. This is clinically significant, as development of symptomatic inguinal hernia leads to pain, poor quality of life, and potential need for surgical repair [18]. While RS-RARP was not associated with a decreased risk of inguinal hernia development on Cox proportional hazards model, given that there were no events in the RS-RARP group, we feel that this is due to a lack of overall events to make this model meaningful, which also highlights the need for further study with increased power to confirm our hypothesis.

Our study must be interpreted within the context of the study design. RS-RARP is a novel and promising surgical approach; however, with new techniques, published series are relatively small and follow-up is limited. A recent survey indicated that it is limited to 30 centers worldwide [19]. Similarly, our major limitation is the small sample size and limited follow-up. This is likely more significant for our Peyronie's disease and inguinal hernia findings, as Tal et al [4] found that the mean time to the development of Peyronie's disease is 13.9 mo, while Alder et al [5] found that most developed within 2–3 yr, and therefore the S-RARP group has had longer time at risk. Additionally, our small sample size did not allow us to discover a significant association between RS-RARP and reduced postoperative Peyronie's disease and inguinal hernia in our Cox proportional hazards model. However, given the complete lack of these events in the RS-RARP group, we still feel that our hypothesis is valid and more power is needed in future study to confirm this. These limitations are less significant for penile shortening as many studies have shown that penile length is usually shortest within 1 yr, and our RS-RARP study population had shorter follow-up than the S-RARP study population [14]. Additionally, there has been no other study examining these outcomes following RS-RARP, and our findings should be considered hypothesis generating and lead to a future prospective study in larger cohorts. Second, this is a retrospective study and our survey measures patient-reported outcomes rather than objective physical examination findings such as stretched penile length (which approximates erect penile length) [10], plaque formation or penile curvature, or inguinal bulge with Valsalva. However, patient distress and bother are patient centered and are not elicited by physical examination findings, and are the driver of patient-initiated care rather than physical examination findings. Moreover, surgical repair of inguinal hernias is an objective endpoint, but may undercapture the difference in these sequelae between surgical techniques.

5. Conclusions

Our study suggests that the differences in the anatomic approach between RS-RARP and S-RARP may result in less patient-perceived penile shortening, Peyronie's disease, and inguinal hernia sequelae. These findings should be considered as hypothesis generating and should lead to a further prospective study with greater power and longer follow-up to examine the role of dorsal vascular complex and pelvic fascia sparing during RS-RARP in preventing such sequelae.

Author contributions: Keith J. Kowalczyk 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: Kowalczyk, Davis, Hu.
Acquisition of data: O'Neill, Lee.
Analysis and interpretation of data: Kowalczyk, Davis, Hu, Orzel, Rubin.
Drafting of the manuscript: Kowalczyk, Davis, Hu.
Critical revision of the manuscript for important intellectual content: Kowalczyk, Davis, Hu, Orzel, Rubin.
Statistical analysis: Kowalczyk.
Obtaining funding: None.
Administrative, technical, or material support: Kowalczyk.

Supervision: Kowalczyk.
Other: None.

Financial disclosures: Keith J. Kowalczyk certifies that all conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript (eg, employment/affiliation, grants or funding, consultancies, honoraria, stock ownership or options, expert testimony, royalties, or patents filed, received, or pending), are the following: None.

Funding/Support and role of the sponsor: None.

***Acknowledgements*:** Medical illustrations were done by David Klemm, Georgetown University Medical Center, Washington, DC, USA.

References

[1] Deveci S, Gotto GT, Alex B, O'Brien K, Mulhall JP. A survey of patient expectations regarding sexual function following radical prostatectomy. BJU Int 2016;118:641–5.

[2] Carlsson S, Nilsson AE, Johansson E, Nyberg T, Akre O, Steineck G. Self-perceived penile shortening after radical prostatectomy. Int J Impot Res 2012;24:179–84.

[3] Mulhall JP, Secin FP, Guillonneau B. Artery sparing radical prostatectomy–myth or reality? J Urol 2008;179:827–31.

[4] Tal R, Heck M, Teloken P, Siegrist T, Nelson CJ, Mulhall JP. Peyronie's disease following radical prostatectomy: Incidence and predictors. J Sex Med 2010;7:1254–61.

[5] Alder R, Zetner D, Rosenberg J. Incidence of inguinal hernia after radical prostatectomy: a systematic review and meta-analysis. J Urol 2020;203:265–74.

[6] Galfano A, Ascione A, Grimaldi S, Petralia G, Strada E, Bocciardi AM. A new anatomic approach for robot-assisted laparoscopic prostatectomy: a feasibility study for completely intrafascial surgery. Eur Urol 2010;58:457–61.

[7] Egan J, Marhamati S, Carvalho F, et al. Retzius-sparing robot-assisted radical prostatectomy leads to durable improvement in urinary function and quality of life versus standard robot-assisted radical prostatectomy without compromise of oncologic efficacy: single surgeon series and step-by-step. Eur Urol 2020. http://dx.doi.org/10.1016/j.eururo.2020.05.010, Jun 11;S0302-2838(20)30350-X. Online ahead of print.

[8] Carlsson S, Nilsson AE, Johansson E, et al. The prevalence of Peyronie's disease: results of a large survey. BJU Int 2001;88:727–30.

[9] Eden CG, Moschonas D, Soares R. Urinary continence four weeks following Retzius-sparing robotic radical prostatectomy: The UK experience. J Clin Urol 2018;11:15–20.

[10] Gontero P, Galzerano M, Bartoletti R, et al. New insights into the pathogenesis of penile shortening after radical prostatectomy and the role of postoperative sexual function. J Urol 2007;178:602–7.

[11] Savoie M, Kim SS, Soloway MS. A prospective study measuring penile length in men treated with radical prostatectomy for prostate cancer. J Urol 2003;169:1462–4.

[12] Lei Y, Alemozaffar M, Williams SB, et al. Athermal division and selective suture ligation of the dorsal vein complex during robot-assisted laparoscopic radical prostatectomy: description of technique and outcomes. Eur Urol 2011;59:235–43.

[13] Cohen D, Gonzalez J, Goldstein I. The role of pelvic floor muscles in male sexual dysfunction and pelvic pain. Sex Med Rev 2016;4:53–62.

[14] Kadono Y, Machioka K, Nakashima K, et al. Changes in penile length after radical prostatectomy: investigation of the underlying anatomical mechanism. BJU Int 2017;120:293–9.

[15] Devine CJ, Somers KD, Jordan GH, Schlossberg SM. Proposal: trauma as the cause of the Peyronie's lesion. J Urol 1997;157:285–90.

[16] Iacono F, Giannella R, Somma P, Manno G, Fusco F, Mirone V. Histological alterations in cavernous tissue after radical prostatectomy. J Urol 2005;173:1673–6.

[17] Wiltz AL, Shikanov S, Eggener SE, et al. Robotic radical prostatectomy in overweight and obese patients: oncological and validated-functional outcomes. Urology 2009;73:316–22.

[18] Chen HR, Ting HK, Kao CC, et al. Robot-assisted radical prostatectomy may induce inguinal hernia within the first 2 years: an 11-year single-surgeon experience of &400 cases. Medicine (Baltimore) 2018;97:e12208.

[19] Olivero A, Galfano A, Piccinelli M, et al. Retzius-sparing robotic radical prostatectomy for surgeons in the learning curve: a propensity score-matching analysis. Eur Urol 2020. http://dx.doi.org/10.1016/j.eururo.2020.05.010, Jun 11;S0302-2838(20)30350-X. Online ahead of print.

THE JOURNAL of UROLOGY®
www.auajournals.org/journal/juro

JU Insight

Comparative Outcomes of Salvage Retzius-Sparing versus Standard Robotic Prostatectomy: An International, Multi-Surgeon Series

Keith J. Kowalczyk, Rabii H. Madi, Christopher G. Eden et al.

Correspondence: Keith J. Kowalczyk (email: keith.kowalczyk@medstar.net).

Full-length article available at www.auajournals.org/doi/10.1097/JU.0000000000001933.

Study Need and Importance: Healthy men experiencing localized high risk prostate cancer recurrence following nonsurgical treatments, including radiation and ablative therapies, are all too often left with very few palatable options for treatment. Unfortunately, definitive surgical management with salvage prostatectomy is rarely offered. This is understandable, as open salvage prostatectomy incontinence rates range from 50%–80% in addition to much higher risk of significant intraoperative complications. Therefore, most men instead opt for treatment with non-curative androgen deprivation therapy, which in addition to significant side effects carries increased risk of cardiovascular disease and thromboembolism. Cryoablation is another option, however even though minimally invasive this also carries up to a 3.4% risk of devastating rectal fistula and 25.3% risk of incontinence.

The advent of robotic surgery made salvage prostatectomy safer; however, incontinence rates remained high and therefore was still largely avoided. With improved urinary outcomes seen with Retzius-sparing robotic prostatectomy, we wanted to see if this benefit also carried over in the salvage setting.

What We Found: Among 72 men undergoing salvage robotic prostatectomy, we found significantly improved continence in men undergoing Retzius-sparing vs standard salvage robotic prostatectomy, with 78.4% vs 43.8% (p=0.003) of men utilizing only 1 pad per day and 54.1% vs 6.3% (p <0.001) completely dry without need for pads (see table). Men undergoing salvage Retzius-sparing prostatectomy also achieved earlier continence (47 vs 180 days, p=0.008) and had lower mean pad per day usage (0.57 vs 2.03 pads per day, p<0.001). Improved continence remained significant for salvage Retzius-sparing robotic prostatectomy on adjusted analysis (HR 0.28, 95% CI 0.10–0.79, p=0.016). Finally, and perhaps most importantly, these surgeries were feasible with few major surgical complications, with biochemical recurrence in only 23.1% of men at the time of publication.

Limitations: Salvage prostatectomy is a rare surgery due to the aforementioned risks; therefore, our study is limited in numbers. Additionally, the retrospective nature of the study is a limitation.

Interpretation for Patient Care: This is the first and largest study to compare salvage Retzius-sparing robotic prostatectomy with salvage standard robotic prostatectomy analyzing patients operated on by expert surgeons across nine international centers. Our hope that these results encourage more surgeons to offer definitive management with salvage Retzius-sparing robotic prostatectomy to healthy men who experience recurrence following nonsurgical management as a viable and safe option that maintains postoperative quality of life.

Table. *Functional outcomes for all subjects*

	Retzius-Sparing Robot-Assisted Prostatectomy (N=40)	Standard Robot-Assisted Prostatectomy (N=32)	p Value
No. continence (%):			
0–1 Pads	29 (78.4)	14 (43.8)	0.003
0 Pads	20 (54.1)	2 (6.3)	<0.001
Median days to continence, 0–1 pads (IQR)	47 (30–168)	180 (119–341)	0.008
Mean pads per day (SD)	0.57 (0.65)	2.03 (1.81)	<0.001
No. postop continence surgery (%)	3 (7.9)	4 (12.5)	0.522
No. potent (%)	4 (10.0)	4 (12.5)	0.769

0022-5347/21/2065-1184/0
THE JOURNAL OF UROLOGY®

https://doi.org/10.1097/JU.0000000000001939
Vol. 206, 1184-1191, November 2021
Printed in U.S.A.

THE JOURNAL of UROLOGY®
www.auajournals.org/journal/juro

Comparative Outcomes of Salvage Retzius-Sparing versus Standard Robotic Prostatectomy: An International, Multi-Surgeon Series

Keith J. Kowalczyk,[1,*] Rabii H. Madi,[2] Christopher G. Eden,[3] Prasanna Sooriakumaran,[3] Karen Fransis,[4] Yannic Raskin,[5] Steven Joniau,[5] Scott Johnson,[6] Kenneth Jacobsohn,[6] Antonio Galfano,[7] Aldo M. Bocciardi,[7] Jonathan Hwang,[1] Isaac Y. Kim[8] and Jim C. Hu[9,†]

[1]*Department of Urology, MedStar Georgetown University Hospital and Washington Hospital Center, Lombardi Cancer Center, Washington, District of Columbia*
[2]*Section of Urology, Department of Surgery, Medical College of Georgia-Augusta University, Georgia Cancer Center, Augusta, Georgia*
[3]*Urology, Santis Clinic, London, United Kingdom*
[4]*Urology, UZA—University Hospital, Antwerp, Belgium*
[5]*Urology, University Hospitals Leuven, Leuven, Belgium*
[6]*Department of Urological Surgery, Medical College of Wisconsin, Milwaukee, Wisconsin*
[7]*Department of Urology, ASST Grande Ospedale Metropolitano Niguarda, Milan, Italy*
[8]*Division of Urology, Section of Urologic Oncology, Rutgers Cancer Institute of New Jersey, Robert Wood Johnson Medical School, New Brunswick, New Jersey*
[9]*Department of Urology, Weill Cornell Medicine, New York, New York*

Purpose: Salvage radical prostatectomy is rare due to the risk of postoperative complications. We compare salvage Retzius-sparing robotic assisted radical prostatectomy (SRS-RARP) with salvage standard robotic assisted radical prostatectomy (SS-RARP).

Materials and Methods: A total of 72 patients across 9 centers were identified (40 SRS-RARP vs 32 SS-RARP). Demographics, perioperative data, and pathological and functional outcomes were compared using Student's t-test and ANOVA. Cox proportional hazard models and Kaplan-Meier curves were constructed to assess risk of incontinence and time to continence. Linear regression models were constructed to investigate postoperative pad use and console time.

Results: Median followup was 23 vs 36 months for SRS-RARP vs SS-RARP. Console time and estimated blood loss favored SRS-RARP. There were no differences in complication rates or oncologic outcomes. SRS-RARP had improved continence (78.4% vs 43.8%, $p < 0.001$ for 0−1 pad, 54.1% vs 6.3%, $p < 0.001$ for 0 pad), lower pads per day (0.57 vs 2.03, $p < 0.001$), and earlier return to continence (median 47 vs 180 days, $p = 0.008$). SRS-RARP was associated with decreased incontinence defined as >0−1 pad (HR 0.28, 95% CI 0.10−0.79, $p = 0.016$), although not when defined as >0 pad (HR 0.56, 95% CI 0.31−1.01, $p = 0.053$). On adjusted analysis SRS-RARP was associated with decreased pads per day. Lymph node dissection and primary treatment with stereotactic body radiation therapy were associated with longer console time.

Conclusions: SRS-RARP is a feasible salvage option with significantly improved urinary function outcomes. This may warrant increased utilization of SRS-RARP to manage men who fail nonsurgical primary treatment for prostate cancer.

Key Words: prostatic neoplasms; prostatectomy; neoplasm recurrence, local

Abbreviations and Acronyms

ADT = androgen deprivation therapy
BMI = body mass index
EBRT = external beam radiation therapy
HIFU = high-intensity focused ultrasound
PSA = prostate specific antigen
PSM = positive surgical margin
RS-RARP = Retzius-sparing robot-assisted radical prostatectomy
SBRT = stereotactic body radiation therapy
S-RARP = standard robot-assisted radical prostatectomy
SRP = salvage radical prostatectomy
SRS-RARP = salvage Retzius-sparing robot-assisted radical prostatectomy
SS-RARP = salvage standard robot-assisted radical prostatectomy

---

Accepted for publication May 16, 2021.

* Correspondence: Department of Urology, MedStar Georgetown University Hospital, Washington, District of Columbia (telephone: 202-444-4922; FAX: 877-625-1478; email: keith.kowalczyk@medstar.net).

† Supported by The Frederick J. and Theresa Dow Wallace Fund of the New York Community Trust, and by Grants PCORI CER-2019C1-15682, PCORI CER-2019C2-17372 and NCI R01 CA241758.

0022-5347/21/2065-1185/0
THE JOURNAL OF UROLOGY®

https://doi.org/10.1097/JU.0000000000001939
Vol. 206, 1184-1191, November 2021
Printed in U.S.A.

OPEN salvage radical prostatectomy (SRP) incontinence rates range from 50%–80%,[1–3] such that the perception of inevitable urinary incontinence has impeded its widespread use. For the 30% of men that opt for primary radiation therapy,[4] 30-60% will experience treatment failure within 5 and 10 years,[5,6] equating to 15,000 U.S. men developing radiation recurrence annually.[7] Most are treated with androgen deprivation therapy while only 3% are offered SRP as a possible chance for cure.[8] Unfortunately, androgen deprivation therapy (ADT) is noncurative and has significant morbidity, such as diabetes, cardiovascular and peripheral vascular disease, depression and venous thromboembolism.[9,10]

The application of robotic surgery to salvage prostatectomy in 2008 led to decreased perioperative morbidity.[11] Although complications decreased, incontinence rates remained high.[12–14] In 2010, Galfano et al described a Retzius-sparing approach to robot-assisted radical prostatectomy (RS-RARP) that preserves the dorsal vascular complex and fascial support structures of the pelvis,[15] which are disrupted during standard robot-assisted radical prostatectomy (S-RARP). Single-center studies demonstrate men undergoing RS-RARP have better urinary function due to preservation of pelvic fascia support structures.[16–19] We hypothesize that salvage RS-RARP (SRS-RARP) better preserves urinary continence than salvage S-RARP (SS-RARP) and offers men a chance at cure. Our objective was to conduct a multi-institutional analysis of SRS-RARP vs SS-RARP to compare functional and oncologic outcomes.

MATERIALS AND METHODS

A total of 87 patients from 9 centers who had undergone robotic SRP following primary non-surgical treatment failure between 2011 and 2020 were identified from individual IRB-approved prospectively collected databases, and outcomes were compiled in a single IRB-approved database (IRB No. MOD00006521). All men had negative standard metastatic workup and biopsy proven recurrence. Fifteen subjects were censored from analysis due to incomplete data, leading to a final study cohort of 72 patients. Among these patients, 40 underwent SRS-RARP and 32 underwent SS-RARP.

Surgical approach was determined by surgeon preference at the time of surgery. All but 2 surgeons (JH, IK) have transitioned completely to RS-RARP, although each RS-RARP surgeon had prior SS-RARP experience and contributed subjects to each cohort. All surgeons are high volume, with a range of 300–3,413 robotic prostatectomies performed among the group. Among all contributing surgeons, a total of 14,184 S-RARP and 2,035 RS-RARP have been performed.

There were no universally applied patient reported quality of life measures among subjects, and therefore a pad per day definition of incontinence is reported and defined as the number of pads used at last follow up. Continence rehabilitation protocols varied between centers, however each surgeon provided preoperative instructions regarding Kegel exercises and referred patients to physical therapy following surgery if needed.

Current recommendations for reporting biopsy specimens following primary radiation therapy are: negative with radiation treatment effect present; adenocarcinoma with treatment effect, no Gleason score assigned; and adenocarcinoma with no treatment effects, Gleason score assigned.[20] We report these Gleason scores when available.

Univariate outcomes were compared utilizing the chi-square test and ANOVA where appropriate, with $p < 0.05$ considered statistically significant. Sensitivity analysis was performed to examine univariate interaction between each surgeon and outcome and we found no significant differences. Categorical variables are defined by mean and standard deviation, while continuous variables are defined by median and interquartile range, except for the number of pads per day as medians did not differ due to low variation. To further control for confounding variables and differences in followup, Cox proportional hazard models were built to explore postoperative continence predictors and Kaplan-Meier curves were constructed to compare time to continence. Linear regression models were constructed to evaluate variables associated with total postoperative pad use per day as well as console time.

RESULTS

Table 1 summarizes baseline demographic and pathological data of each cohort. There were no differences in age, body mass index (BMI), prostate specific antigen (PSA) or Gleason grade between cohorts. More subjects in the SRS-RARP cohort underwent high-intensity focused ultrasound (HIFU) as a primary treatment. In contrast, more patients in the SS-RARP cohort underwent cryoablation and stereotactic body radiation therapy (SBRT; $p=0.007$). Additionally, SS-RARP vs SRS-

Table 1. *Baseline clinical and pathological data*

	SRS-RARP (N=40)		SS-RARP (N=32)		p Value
Median yrs age (IQR)	68	(63–70)	66	(60–70)	0.804
Median kg/m^2 BMI (IQR)	27.7	(26–30.9)	28.2	(25.7–32.5)	0.575
No. primary treatment (%):					0.007
EBRT	21	(52.5)	16	(50.0)	
Brachytherapy	12	(30.0)	9	(28.1)	
Cryoablation	0	(0)	5	(15.6)	
SBRT	0	(0)	2	(6.25)	
HIFU	7	(17.5)	0	(0)	
Median ng/ml PSA at surgery (IQR)	4.6	(2.6–8.3)	4.1	(2.7–6.6)	0.876
No. biopsy Gleason group (%):					0.487
1	9	(23.7)	2	(6.9)	
2	9	(23.7)	8	(27.6)	
3	8	(21.1)	8	(27.6)	
4	5	(13.2)	5	(17.2)	
5	7	(18.4)	6	(20.7)	
Pos with radiation effect	2	(5.0)	3	(9.4)	
Median mos from surgery (IQR)	23	(14–33)	36	(20–69)	0.007

Table 2. *Perioperative outcomes*

	RS-RARP (N=40)		S-RARP (N=32)		p Value
Median mins console time (IQR)	130 (115–190)		175 (150–224)		0.014
No. nerve-sparing (%)	19	(47.5)	14	(43.8)	0.751
No. lymph node dissection (%)	32	(80.0)	27	(84.4)	0.632
Median ml estimated blood loss (IQR)	100	(50–200)	150 (100–200)		0.039
Median days catheterization (IQR)*	14	(9–14)	33	(21–45)	0.001
No. intraop complication (%)	1	(2.5)	0	(0)	0.368
No. postop complication (%)	5	(12.5)	9	(28.1)	0.096
No. Clavien grade (%):					0.065
1	2	(40)	1	(11.1)	
2	1	(20)	0	(0)	
3	1	(20)	8	(88.9)	
4	0	(0)	0	(0)	
5	1	(20)	0	(0)	

*Foley catheterization following prostatectomy is standard, and length of catheterization implies healing time.

Table 3. *Pathological outcomes*

	RS-RARP (N=40)		SS-RARP (N=32)		p Value
Median gm prostate weight (IQR)	32 (28–39.6)		39.6 (27–54)		0.189
No. Gleason group (%):					0.845
1	1	(2.7)	1	(3.3)	
2	9	(24.3)	4	(13.3)	
3	12	(32.4)	11	(36.7)	
4	4	(10.8)	3	(10.0)	
5	11	(29.7)	11	(36.7)	
No. stage (%):					0.027
T2	20	(50)	10	(31.2)	
T3a	8	(20)	16	(50)	
T3b	12	(30)	6	(18.8)	
No. pos surgical margin (%):	23	(57.5)	21	(65.6)	0.482
Nonfocal	7	(17.5)	8	(23.0)	0.391
T2	9	(22.5)	6	(18.8)	0.246
T3a	6	(15.0)	10	(31.2)	
T3b	8	(20.0)	5	(15.6)	
No. lymph node pos (%)	7	(17.5)	3	(9.4)	0.203
No. biochemical recurrence (%)	9	(23.1)	12	(37.5)	0.185
No. adjuvant ADT (%)	5	(12.8)	5	(15.6)	0.735

RARP subjects had longer median followup (36 vs 23 months, p=0.007).

Table 2 details perioperative outcomes between cohorts. SRS-RARP had a shorter console time (130 vs 175 minutes, p=0.014), less blood loss (100 vs 150 ml, 0=0.039), and shorter catheterization times (13 vs 33 days, p=0.001). Complication rates did not differ, with 12.5% vs 28.1% complication rates for SRS-RARP vs SS-RARP (p=0.096). Clavien grades also did not differ, with all but one complication having Clavien grades of 3 or lower. One patient in the SRS-RARP cohort had a cardiac arrest following discharge leading to mortality. One patient in the SRS-RARP cohort required intraoperative ureteral reimplantation; however, this did not lead to a significantly altered postoperative course and was therefore not reported according to Clavien grade. There were no rectal injuries in either cohort.

Table 3 summarizes postoperative pathological outcomes. More subjects in the SRS-RARP cohort had stage pT2 and pT3b disease, while more patients in the SS-RARP cohort had pT3a disease (p=0.027). There were no differences in overall positive surgical margins (PSM) between cohorts (57.5% vs 65.6%, p=0.482), and these differences remained non-significant when compared by stage. The majority of PSM were focal, with only 17.5% vs 23% incidence of non-focal PSM in SRS-RARP vs SS-RARP, respectively (p=0.391). Lymph node positivity, biochemical recurrence, and the need for adjuvant hormonal therapy were the same.

Table 4 summarizes urinary and sexual function recovery. More men undergoing SRS-RARP vs SS-RARP were continent (0–1 pad per day: 78.4% vs 43.8%, p=0.003; 0 pad per day: 54.1% vs 6.3%, p <0.001). Median time to continence (0–1 pad) was shorter for SRS-RARP vs SS-RARP (47 vs 180 days, p=0.08), and mean pad use per day was lower for SRS-RARP (0.57 vs 2.03 pads, p <0.001). There were no differences in potency or postoperative continence surgery. Table 4 shows results in men who only underwent primary radiation modalities, and these findings remained consistent.

Cox proportional hazard models (table 5) show that men undergoing SRS-RARP were less likely to experience incontinence defined as >0–1 pad (HR 0.28, 95% CI 0.10–0.79, p=0.016, table 5); however, this was not the case when defined as >0 pad (HR 0.56, 95% CI 0.31–1.01, p=0.053). Kaplain-Meier curves show earlier return to continence in the SRS-RARP group vs the SS-RARP for both 0-1 pad and 0-pad definitions (see figure). Finally, multivariate linear regression demonstrated that SRS-RARP vs SS-RARP was associated with less postoperative pad use (table 6; parameter estimate −1.73, standard error 0.42, p <0.001).

Table 4. *Functional outcomes for all subjects and those only undergoing primary radiation modalities*

	RS-RARP		S-RARP		p Value
All subjects					
Total No. subjects	40		32		
No. continence (%):					
0–1 Pads	29	(78.4)	14	(43.8)	0.003
0 Pads	20	(54.1)	2	(6.3)	<0.001
Median days to continence, 0–1 pad days (IQR)	47 (30–168)		180 (119–341)		0.008
Mean pads per day (SD)	0.57	(0.65)	2.03	(1.81)	<0.001
No. postop continence surgery (%)	3	(7.9)	4	(12.5)	0.522
No. potent (%)	4	(10.0)	4	(12.5)	0.769
Only subjects receiving primary radiation modalities					
Total No. subjects	33		27		
No. continence (%):					
0–1 Pads	24	(80.0)	12	(44.4)	0.005
0 Pads	16	(53.3)	2	(7.4)	<0.001
Median days time to continence, 0–1 pad (IQR)	90 (30–176)		180 (180–321)		0.001
Mean pads per day (SD)	0.53	(0.57)	2.12	(1.94)	0.001
No. postop continence surgery (%)	3	(9.1)	4	(14.8)	0.549
No. potent (%)	2	(6.1)	2	(7.4)	0.886

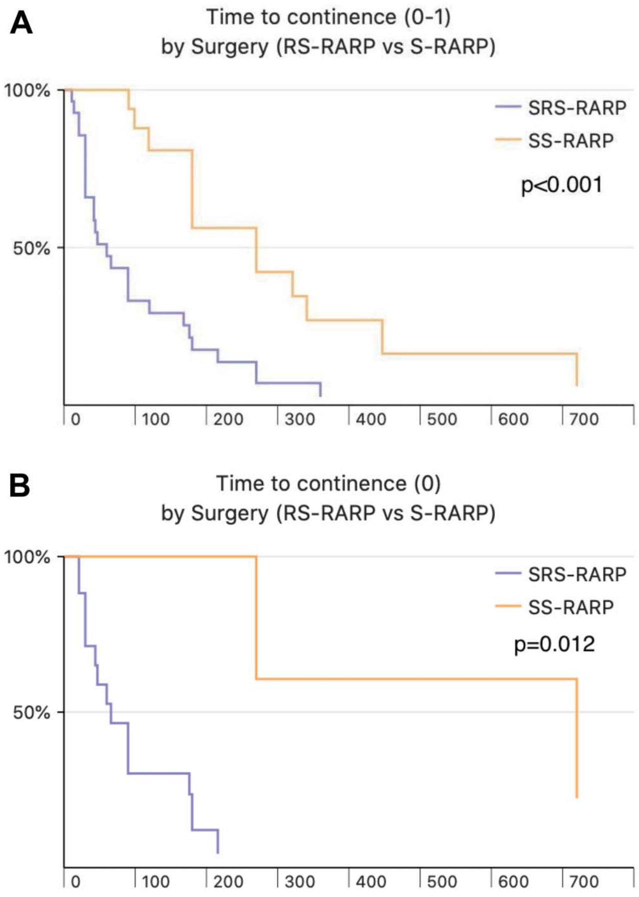
Table 5. *Cox proportional hazards model for variables related to postoperative continence, defined as both 0–1 pads and 0 pads per day*

	0–1 Pads per Day				0 Pads per Day			
	HR	95% CI		p Value	HR	95% CI		p Value
Age	1.04	0.96	1.11	0.359	1.02	0.98	1.07	0.405
Mos from surgery	0.99	0.98	1.11	0.511	1.00	0.99	1.01	0.983
BMI	1.06	0.98	1.15	0.141	1.01	0.96	1.06	0.587
RS-RARP vs S-RARP	0.28	0.10	0.79	0.016	0.56	0.29	1.08	0.085
Nerve-sparing	1.32	0.53	3.31	0.546	1.15	0.64	1.95	0.702
Stage (reference: T2):								
T3a	0.68	0.23	2.03	0.494	1.20	0.63	2.28	0.585
T3b	1.65	0.58	4.65	0.346	1.29	0.66	2.54	0.457
Primary treatment (reference: brachytherapy):								
Cryoablation	0.50	0.10	2.56	0.402	0.96	0.32	2.86	0.945
EBRT	0.45	0.16	1.32	0.146	0.80	0.45	1.43	0.452
HIFU	1.48	0.25	8.64	0.663	0.90	0.34	2.38	0.830
SBRT	0.83	0.09	7.81	0.870	0.89	0.19	4.23	0.879

Table 6. *Linear regression of variables related to total postoperative pad number*

	Parameter Estimate	Standard Error	p Value
Age	0.03	0.03	0.394
Mos from surgery	−0.01	0.01	0.496
Primary treatment (reference: cryoablation):			
Brachytherapy	0.93	0.76	0.227
EBRT	0.77	0.74	0.303
HIFU	0.92	0.93	0.325
SBRT	0.79	0.79	0.529
RS-RARP vs S-RARP	−1.73	0.42	<0.001
Nerve-sparing	0.28	0.39	0.472
Stage (reference: T2):			
T3a	0.07	0.44	0.872
T3b	0.17	0.47	0.720

Although SRS-RARP vs SS-RARP had lower median console time on univariate analysis, this difference was no longer significant on multivariate analysis. However, primary treatment of SBRT (PE 86.9, standard error 37.2, p=0.023) and lymph node dissection (PE 50.6, standard error 14.6, p <0.001) were both associated with longer console times (table 7).



Kaplan-Meier curves of time to continence, defined as both 0–1 (*A*) and 0 (*B*) pads per day.

DISCUSSION

Historically, SRP has been underutilized due to high rates of incontinence and sexual dysfunction. Additionally, surgical planes are disrupted from primary radiation or ablative treatments leading to the potential increase in intraoperative complications, such as bleeding and rectal injury. As such, salvage prostatectomy has traditionally been thought of as a "last resort" surgery, with most men instead treated with ADT, which can have debilitating side effects.

The first successful SS-RARP was reported by Jamal et al in 2008[11] and has led to subsequent decreased perioperative morbidity following SRP.[12–14] Although complications decreased, incontinence rates remained higher than primary S-RARP, making this approach still less desirable than other salvage options. However, primary RS-RARP has been shown to have significantly improved short-term and long-term urinary function outcomes. Therefore, we hypothesized that SRS-RARP would lead to decreased morbidity while maintaining acceptable urinary quality of life, making this a more appealing treatment option in men with recurrence following primary nonsurgical treatment, who are often not offered a chance for cancer cure following recurrence.

Our study has many significant findings. First, we find that robot-assisted SRP by either approach is safe and feasible with fewer complications than previously reported and with comparable complication rates to other salvage options. Prasad et al. found that up to 60.1% of open SRP had complications, and 30.4% required hospital readmission within 30 days in a survey of SEER-Medicare data.[21] In contrast, complications occurred in only

Table 7. *Linear regression of variables related to console time*

	Parameter Estimate	Standard Error	p Value
Surgeon	3.99	2.14	0.067
BMI	0.68	1.14	0.552
Primary treatment (reference: cryoablation):			
Brachytherapy	30.9	27.1	0.260
EBRT	15.4	27.0	0.570
HIFU	40.0	30.2	0.190
SBRT	86.9	37.2	0.023
RS-RARP vs S-RARP	−18.9	14.8	0.205
Lymph node dissection	50.6	14.6	<0.001
Stage (reference T2):			
T3a	10.2	13.4	0.452
T3b	26.6	13.9	0.061

12.5% and 28.1% of men undergoing SRS-RARP and SS-RARP in our series, respectively. These outcomes are consistent with prior SS-RARP series, with complication rates ranging from 8% to 39%.[12,22,23] In another series of 68 men undergoing SS-RARP, 26% experienced complications overall (with anastomotic leak being the most common), with four major complications and no rectal injuries.[24] This decrease in complications following both SRS-RARP and SS-RARP should lead to increased comfort with SRP as a standard option for men with recurrent disease following nonsurgical management, rather than a last-resort surgery.

Second, SRS-RARP significantly improves postoperative continence outcomes compared to SS-RARP, with 78.4% vs 43.8% of men reporting 0–1 pad use per day, respectively. We also found that men undergoing SRS-RARP had earlier return to continence (median 47 vs 180 days). Our SRS-RARP findings compare favorably and frequently exceed those in prior SS-RARP series, with social continence varying between 33% and 60%,[12,14,22,23] while open SRP incontinence rates have varied between 50%–80%.[1–3] Additionally, in adjusted analyses, SS-RARP was associated with better continence using both the 0 and 0-1 pad definitions and decreased total pad per day usage.[24] These findings suggest that SRS-RARP is a viable alternative to other post-radiation salvage therapies that may significantly maintain quality of life postoperatively compared to SS-RARP. However, it is still notable that fewer men achieve the 0 pad definition of continence following each salvage approach, and therefore managing patient expectations regarding postoperative continence outcomes remains crucial.

Third, oncologic outcomes are equivalent to other salvage treatments. We report 23.1% vs 37.5% BCR for SRS-RARP vs SS-RARP, respectively. Additionally, only 12.8% and 15.6% of men undergoing SRS-RARP and SS-RARP, respectively, required adjuvant hormonal treatment postoperatively, avoiding the debilitating side effects of such therapy.[9,25,26] However, with relatively limited followup, more time is needed for more meaningful evaluation of postoperative biochemical recurrence. This echoes prior studies examining oncologic outcomes of SRP. Chade et al. reported 37% BCRFS, 77% metastasis-free survival and 83% cancer-specific survival with a median follow-p of 4.4 years following open SRP.[13] Like our series, oncologic outcomes following SS-RARP have compared favorably to open SRP. Kaffenberger et al reported 18% BCRFS at a median followup of 48.5 months, finding that preoperative PSA doubling time had the most significant association with BCRFS.[14] Likewise, Eandi et al reported 67% BCRFS at 18 months following SS-RARP.[12]

PSM remained relatively high in our series, with SRS-RARP and SS-RARP PSM rates of 56.4% and 76.9%, respectively. The majority of PSM were in men with pT3 or greater disease, with pT2 PSM incidence of 22.5% and 18.8% in SRS-RARP and SS-RARP, respectively. Prior SS-RARP series have reported PSM incidence ranging from 28% to 39%,[12,14,23,27] which is comparable to open SRP PSM incidence of 25% reported by Chade et al.[13] Our higher PSM rate may be due to large numbers of nerve-sparing procedures within our cohort, with 45.8% of men among both groups undergoing at least partial nerve-sparing. Others have shown the inaccuracy of magnetic resonance imaging to predict T-stage in the salvage setting, and thus, nerve-sparing should be avoided in most salvage prostatectomy cases.[28] As our study was a multi-institutional retrospective review, magnetic resonance imaging utilization and review was not consistent among centers, leading to varied approaches to nerve-sparing. We feel that the preponderance of nerve-sparing in our series is the most likely reason for the high PSM rates rather than the surgical approach. Additionally, we report the overall incidence of focal and nonfocal PSM, and the incidence of nonfocal PSM in our series is similar to those previously reported.

Finally, potency remains problematic following SRP via any approach. Prior SS-RARP series have reported potency ranging from 5% to 26%,[22,23] although Ogaya-Pinies et al reported 55% postoperative potency as defined as SHIM >21 in a subanalysis of preoperatively potent men.[24] Similarly, we report potency in 10% and 12.5% following SRS-RARP and SS-RARP, respectively. However, potency and sexual side effects remain problematic following most salvage therapies, including focal and full gland cryoablation[29] and in >90% of men undergoing noncurative ADT.[25,26] A more recent review of 53 men undergoing SS-RARP following primary HIFU, 0% achieved potency postoperatively.[30] Therefore, it is crucial to put these outcomes in the context of other available options.

Our study must be considered in the context of the study design. First, this is a retrospective analysis and may suffer from biases inherent in retrospective data collection. Second, there is unequal followup between cohorts and differences in primary treatment modalities, affecting time-sensitive outcomes. Longer followup will almost certainly lead to increasing rates of BCR. However, the lower incidence of PSM in the SRS-RARP cohort should imply at least non-inferiority regarding BCR with longer followup. Additionally, differences in primary treatment were controlled in multivariate analyses and continence outcomes still significantly favored SRS-RARP. Finally, PSM rates in our study were higher than in previous studies in both cohorts. However, prior studies have mostly been single-center or single surgeon series. Our series is across 9 centers and may represent a broader and more accurate representation of PSM incidence following SRP. High PSM incidence may also be explained by high rates of nerve-sparing in our cohort, with 45.8% undergoing at least partial nerve-sparing, which increases the risk of PSM.[28] Additionally, prior studies have not defined whether reporting just focal or extensive margins. In contrast, our study reports all positive margins regardless of extent, which may also explain a higher incidence of PSM. Finally, given the variety of centers reporting in our study and lack of central pathological examination, heterogeneity in pathological reporting may have also led to higher margins. Despite these differences, BCR incidence and ADT utilization remain low. Further followup is needed to see if increased PSM will lead to higher recurrence rates in these cohorts.

CONCLUSIONS

To our knowledge, this is the largest and only multinational, multi-surgeon series comparing outcomes of SRS-RARP and SS-RARP. We demonstrate that both SRS-RARP and SS-RARP are feasible and relatively safe procedures in terms of perioperative risk. However, SRS-RARP offers significant advantages in maintaining urinary continence and quality of life compared to SS-RARP. These acceptable outcomes may warrant increased utilization of SRS-RARP to manage the large number of men who will fail non-surgical primary treatment for prostate cancer.

REFERENCES

1. Ward JF, Sebo TJ, Blute ML et al: Salvage surgery for radiorecurrent prostate cancer: contemporary outcomes. J Urol 2005; **173:** 1156.
2. Bianco FJ, Scardino PT, Stephenson AJ et al: Long-term oncologic results of salvage radical prostatectomy for locally recurrent prostate cancer after radiotherapy. Int J Radiat Oncol Biol Phys 2005; **62:** 448.
3. Stephenson AJ, Scardino PT, Bianco FJ et al: Morbidity and functional outcomes of salvage radical prostatectomy for locally recurrent prostate cancer after radiation therapy. J Urol 2004; **172:** 2239.
4. Mahal BA, Butler S, Franco I et al: Use of active surveillance or watchful waiting for low-risk prostate cancer and management trends across risk groups in the United States, 2010—2015. JAMA 2019; **321:** 704.
5. Bolla M, Van Tienhoven G, Warde P et al: External irradiation with or without long-term androgen suppression for prostate cancer with high metastatic risk: 10-year results of an EORTC randomised study. Lancet Oncol 2010; **11:** 1066.
6. Zapatero A, Mínguez R, Nieto S et al: Post-treatment prostate biopsies in the era of three-dimensional conformal radiotherapy: what can they teach us? Eur Urol 2009; **55:** 902.
7. Jones JS: Radiorecurrent prostate cancer: an emerging and largely mismanaged epidemic. Eur Urol 2011; **60:** 411.
8. Agarwal PK, Sadetsky N, Konety BR et al: Treatment failure after primary and salvage therapy for prostate cancer: likelihood, patterns of care, and outcomes. Cancer 2008; **112:** 307.
9. Hu JC, Williams SB, O'Malley AJ et al: Androgen-deprivation therapy for nonmetastatic prostate cancer is associated with an increased risk of peripheral arterial disease and venous thromboembolism. Eur Urol 2012; **61:** 1119.
10. Keating NL, O'Malley AJ and Smith MR: Diabetes and cardiovascular disease during androgen deprivation therapy for prostate cancer. J Clin Oncol 2006; **24:** 4448.
11. Jamal K, Challacombe B, Elhage O et al: Successful salvage robotic-assisted radical prostatectomy after external beam radiotherapy failure. Urology 2008; **72:** 1356.
12. Eandi JA, Link BA, Nelson RA et al: Robotic assisted laparoscopic salvage prostatectomy for radiation resistant prostate cancer. J Urol 2010; **183:** 133.
13. Chade DC, Shariat SF, Cronin AM et al: Salvage radical prostatectomy for radiation-recurrent prostate cancer: a multi-institutional collaboration. Eur Urol 2011; **60:** 205.
14. Kaffenberger SD, Keegan KA, Bansal NK et al: Salvage robotic assisted laparoscopic radical prostatectomy: a single institution, 5-year experience. J Urol 2013; **189:** 507.
15. Galfano A, Ascione A, Grimaldi S et al: A new anatomic approach for robot-assisted laparoscopic prostatectomy: a feasibility study for completely intrafascial surgery. Eur Urol 2010; **58:** 457.
16. Sayyid RK, Simpson WG, Lu C et al: Retzius-sparing robotic-assisted laparoscopic radical prostatectomy: a safe surgical technique with superior continence outcomes. J Endourol 2017; **31:** 1244.
17. Dalela D, Jeong W, Prasad MA et al: A pragmatic randomized controlled trial examining the impact of the Retzius-sparing approach on early urinary continence recovery after robot-assisted radical prostatectomy. Eur Urol 2017; **72:** 677.
18. Egan J, Marhamati S, Carvalho FLF et al: Retzius-sparing robot-assisted radical prostatectomy leads to durable improvement in urinary function and quality of life versus standard robot-assisted radical prostatectomy without compromise on oncologic efficacy: single-surgeon series and step-by-step guide. Eur Urol 2021; **79:** 839.
19. Umari P, Eden C, Cahill D et al: Retzius-sparing versus standard robot-assisted radical prostatectomy: a comparative prospective study of nearly 500 patients. J Urol 2021; **205:** 780.
20. Evans AJ: Treatment effects in prostate cancer. Mod Pathol 2018; **31:** S110.

21. Prasad SM, Gu X, Kowalczyk KJ et al: Morbidity and costs of salvage vs primary radical prostatectomy in older men. Urol Oncol 2013; **31:** 1477.

22. Zargar H, Lamb AD, Rocco B et al: Salvage robotic prostatectomy for radio recurrent prostate cancer: technical challenges and outcome analysis. Minerva Urol Nefrol 2017; **69:** 26.

23. De Groote R, Nathan A, De Bleser E et al: Techniques and outcomes of salvage robot-assisted radical prostatectomy (sRARP). Eur Urol 2020; **78:** 885.

24. Ogaya-Pinies G, Linares-Espinos E, Hernandez-Cardona E et al: Salvage robotic-assisted radical prostatectomy: oncologic and functional outcomes from two high-volume institutions. World J Urol 2019; **37:** 1499.

25. Magee DE and Singal RK: Androgen deprivation therapy: indications, methods of utilization, side effects and their management. Can J Urol 2020; **27:** 11.

26. Magee DE, Hird AE, Klaassen Z et al: Adverse event profile for immunotherapy agents compared with chemotherapy in solid organ tumors: a systematic review and meta-analysis of randomized clinical trials. Ann Oncol 2020; **31:** 50.

27. Marra G, Karnes RJ, Calleris G et al: Oncological outcomes of salvage radical prostatectomy for recurrent prostate cancer in the contemporary era: a multicenter retrospective study. Urol Oncol 2021; **39:** 296.e21.

28. Thompson JE, Sridhar AN, Tan WS et al: Pathological findings and magnetic resonance imaging concordance at salvage radical prostatectomy for local recurrence following partial ablation using high intensity focused ultrasound. J Urol 2019; **201:** 1134.

29. Boissier R, Sanguedolce F, Territo A et al: Partial salvage cryoablation of the prostate for local recurrent prostate cancer after primary radiotherapy: step-by-step technique and outcomes. Urol Video J 2020; **7:** 100040.

30. Thompson JE, Sridhar AN, Shaw G et al: Perioperative, functional and early oncologic outcomes of salvage robotic-assisted radical prostatectomy after high-intensity focused ultrasound partial ablation. BMC Urol 2020; **20:** 81.

EDITORIAL COMMENT

Salvage surgery following radiation therapy remains a neglected surgery. Half of radiation recurrences have a significant therapeutic window for receiving a definitive cure; however, 90% of men will receive ADT,[1,2] losing the chance of a cancer-free status and also being destined to ADT-related side effects. This compromise was justified by the poor functional results together with the relevant complication rates historically associated with SRP. Although an increasing number of contemporary reports show a promising turnaround, with reduced comorbidities, we are still far from a primary setting as one on four patients remains severely incontinent and one on six experiences high-grade complications.[2]

Retzius-sparing surgery provides early continence recovery although no relevant functional and oncological differences with standard approaches are present at 1 year.[3] Nonetheless, surgery is indeed more complex in a salvage compared to a treatment-naïve context due to radiation-induced changes, including tissue inflammation, fibrosis and neo-angiogenesis favoring disruption of surgical planes and periprostatic anatomy.[2] Hence, theoretical benefits of Retzius-space preservation may be enhanced in the context of structures already altered by radiations, possibly resulting in clinically relevant improvements, especially in continence, which is usually much lower for SRP.

Despite some limitations, Kowalczyk and colleagues should be commended for their timely report on Retzius-sparing surgery in a salvage context. They provide a preliminary relevant insight of this technique and, possibly, identify an additional opportunity to improve patient outcomes. As per Retzius-sparing in primary radical prostatectomy, results claim further high-quality assessment to verify whether advantages are consistent. If confirmed, salvage radical prostatectomy in expert hands may increasingly constitute a potential and valid curative alternative to indiscriminate ADT use for prostate cancer recurrences after radiation.

Giancarlo Marra[1,2,3]

[1] *Department of Surgical Sciences, Città della Salute e della Scienza and University of Turin, Turin, Italy*

[2] *Department of Urology, Institut Mutualiste Montsouris Paris, France*

[3] *Department of Urology and Clinical Research Group on Predictive Onco-urology, APHP, Sorbonne University, Paris, France*

REFERENCES

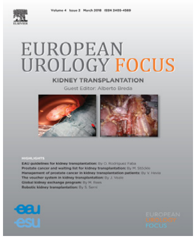
1. Cooperberg MR, Broering JM and Carroll PR: Time trends and local variation in primary treatment of localized prostate cancer. J Clin Oncol 2010; **28:** 1117.

2. Gontero P, Marra G, Alessio P et al: Salvage radical prostatectomy for recurrent prostate cancer: morbidity and functional outcomes from a large multicenter series of open versus robotic approaches. J Urol 2019; **202:** 725.

3. Rosenberg JE, Jung JH, Edgerton Z et al: Retzius-sparing versus standard robotic-assisted laparoscopic prostatectomy for the treatment of clinically localized prostate cancer. Cochrane Database Syst Rev 2020; **8:** CD013641.

EUROPEAN UROLOGY FOCUS XXX (2021) XXX–XXX

available at www.sciencedirect.com
journal homepage: www.europeanurology.com/eufocus



Surgery in Motion

Clipless Robotic-assisted Radical Prostatectomy and Impact on Outcomes

Spyridon P. Basourakos [a], *Patrick J. Lewicki* [a], *Ashwin Ramaswamy* [a], *Emily Cheng* [a], *Vanessa Dudley* [a], *Miko Yu* [a], *Beerinder Karir* [b], *Andrew J. Hung* [c], *Francesca Khani* [b], *Jim C. Hu* [a,*]

[a] *Department of Urology, New York Presbyterian Hospital, Weill Cornell Medicine, New York, NY, USA;* [b] *Department of Pathology and Laboratory Medicine, New York Presbyterian Hospital, Weill Cornell Medicine, New York, NY, USA;* [c] *Department of Urology, University of Southern California Institute of Urology, Los Angeles, CA, USA*

Article info

Article history:
Accepted June 23, 2021

Associate Editor:
Derya Tilki

Keywords:
Prostatectomy
Outcomes
Prostate cancer
Bipolar energy

Please visit www.europeanurology.com and www.urosource.com to view the accompanying video.

Abstract

Background: The use of surgical clips for athermal dissection of the lateral prostatic pedicles and ligation during pelvic lymph node dissection (PLND) while performing robotic-assisted radical prostatectomy (RARP) has been the gold standard. Clips are used to prevent thermal injury of the unmyelinated nerve fibers and lymphceles, respectively.
Objective: To compare oncological and functional outcomes of a new technique of clipless, lateral pedicle control and PLND with RARP with bipolar energy (RARP-bi) versus the standard RARP technique with clips (RARP-c).
Design, setting, and participants: A retrospective study was conducted among 338 men who underwent RARP between July 2018 and March 2020.
Surgical procedure: RARP-c versus RARP-bi.
Measurements: We prospectively collected data and retrospectively compared demographic, clinicopathological, and functional outcome data. Urinary as well as sexual function was assessed using the Expanded Prostate Cancer Index for Clinical Practice, and complications were assessed using Clavien-Dindo grading. Multivariable regression modeling was used to examine whether the technical approach of RARP-bi versus RARP-c was associated with positive surgical margins (PSMs) or sexual and urinary function scores.
Results and limitations: A total of 144 (43%) and 194 (57%) men underwent RARP-bi and RARP-c, respectively. Overall, there were no differences in functional and oncological outcomes between the two approaches. On multivariable regression analysis, the RARP-bi technique was not associated with significant differences in PSMs (odds ratio [OR] = 1.04, 95% confidence interval [CI] 0.6–1.8; $p = 0.9$), sexual function (OR = 0.4, 95% CI 0.1–1.5; $p = 0.8$), or urinary function (OR = 0.5, 95% CI 0.2–1.4; $p = 0.2$). The overall 30-d complication rates (12% vs 16%, $p = 0.5$) and bladder neck contracture rates (2.1% vs 3.6%, $p = 0.5$) were similar between the two groups. There was no difference in lymphocele complications (1.4% vs 0.52%, $p = 0.58$). All complications were of Clavien-Dindo grade I–II.
Conclusions: Despite the concerns for an increased risk of nerve injury secondary to the use of bipolar energy for prostatic pedicle dissection, we demonstrate that this technique is oncologically and functionally similar to the standard approach with surgical

---

[*] Corresponding author. Department of Urology, New York Presbyterian Hospital – Weill Cornell Medicine, 525 East 68th Street, Starr 900, New York, NY 10065, USA.
E-mail address: jch9011@med.cornell.edu (J.C. Hu).

https://doi.org/10.1016/j.euf.2021.06.010

Please cite this article in press as: Basourakos SP, et al. Clipless Robotic-assisted Radical Prostatectomy and Impact on Outcomes. Eur Urol Focus (2021), https://doi.org/10.1016/j.euf.2021.06.010

clips. There was no difference in complications or lymphocele formation for techniques with versus without clips.

Patient summary: We describe a modified technique for prostatic pedicle dissection during robotic-assisted radical prostatectomy, which utilizes bipolar energy and is associated with shorter operative time, without compromising functional or oncological outcomes.

1. Introduction

The preservation of the unmyelinated neurovascular bundle (NVB) is essential for sexual function recovery after radical prostatectomy. Since the initial description of nerve-sparing prostatectomy by Walsh [1], many refinements in nerve-sparing techniques have been proposed. Ong et al [2] demonstrated that the use of hemostatic energy sources in proximity to the prostate during dissection of the NVB impairs the erectile response to cavernous nerve stimulation in a canine model. Furthermore, Hefermehl et al [3] demonstrated that cautery use spreads heat to surrounding structures. Thus, energy-free dissection of the lateral prostatic pedicles has been applied by surgeons for years in an attempt to minimize potential damage to the NVB. Examples of these techniques include the use of bulldog clamps, suture ligation, stapling devices, and surgical clips [4,5].

Robotic-assisted radical prostatectomy (RARP) has become the most popular treatment option for localized prostate cancer, and surgical clips are widely used for thermal energy-free pedicle control during RARP [1,6]. However, the use of clips has been associated with complications, such as clip migration, bladder neck contracture, and stone formation [7,8]. Moreover, a recent randomized trial did not demonstrate a difference in lymphocele formation with bipolar versus clip ligation during pelvic lymph node dissection (PLND) [9]. Additionally, other surgical fields, such as otolaryngology and neurosurgery, use bipolar energy for hemostatic control in areas where thermal spread from the forceps to the surrounding neural tissue is a concern [10,11].

To investigate the potential tradeoffs of clipless RARP, we investigated the use of bipolar energy for the dissection of lateral prostatic pedicles and pelvic lymph nodes. We hypothesized that prostatic pedicle ligation with bipolar energy would have similar oncological and functional outcomes, no difference in lymphoceles, as well as a lower likelihood of clip migration or stricture formation.

2. Patients and methods

2.1. *Patient population and data collection*

From April 2015 through March 2020, a total of 338 consecutive men underwent RARP by a single experienced surgeon (J.C.H.) at New York Presbyterian Hospital/Weill Cornell Medicine. Patients with prior radiation, focal therapy, or androgen deprivation therapy for prostate cancer were excluded. In July 2018, our technique was modified to avoid the use of surgical polymer clips for the control of the lateral prostatic pedicles, for the ligation of the vas deferens, and during the PLND. Data were prospectively collected and retrospectively analyzed after institutional review board approval (WCM-1512016820). Outcomes of 194 men undergoing RARP with clips (RARP-c) from April 2015 to July 2018 were retrospectively compared with 144 men undergoing RARP with bipolar energy (RARP-bi) from August 2018 to March 2020 after our technique change.

2.2. *Surgical technique and modified dissection of the lateral prostatic pedicles*

All men underwent a transperitoneal RARP with a five-port configuration (Fig. 1) via an anterior approach using DaVinci Xi (Intuitive Surgical, Sunnyvale, CA, USA). The elimination of the sixth port during RARP-bi was made possible with the elimination of Hem-o-lok clips (Teleex Medical, Durham, NC, USA). The entire procedure was performed with a 0° lens. The steps of our technique have previously been described and involve preservation of the bladder neck, endopelvic fascia, and urethral length as well as tension-free nerve sparing [12–14]. We used the confluence of the anterior and posterior prostate contours and the distal fold of the lateral pedicle as landmarks for lateral prostatic pedicle ligation. The RARP-c technique involves the placement of Hem-o-lok clips on both the stay and the specimen side to avoid back-bleeding. Subsequently, sharp dissection is performed with cold scissors (Fig. 2A). The RARP-bi technique first involves cauterization of the pedicle with the

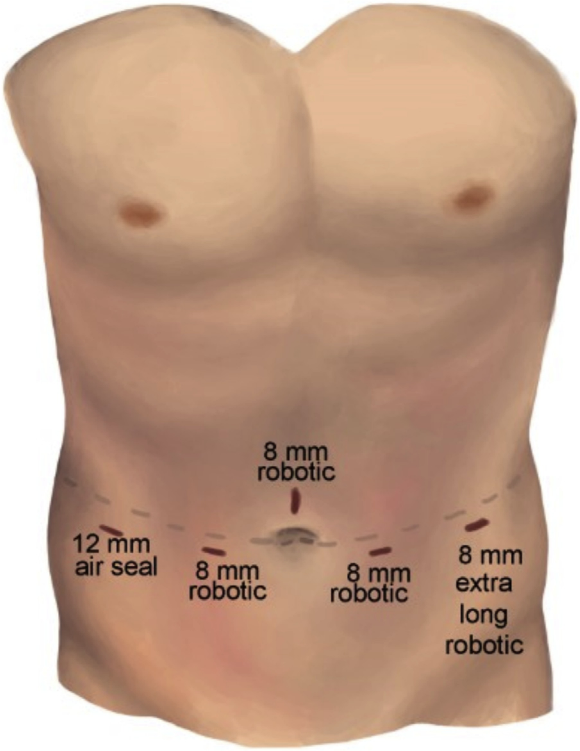


Fig. 1 – Port placement configuration for RARP. RARP = robotic-assisted radical prostatectomy.

Please cite this article in press as: Basourakos SP, et al. Clipless Robotic-assisted Radical Prostatectomy and Impact on Outcomes. Eur Urol Focus (2021), https://doi.org/10.1016/j.euf.2021.06.010

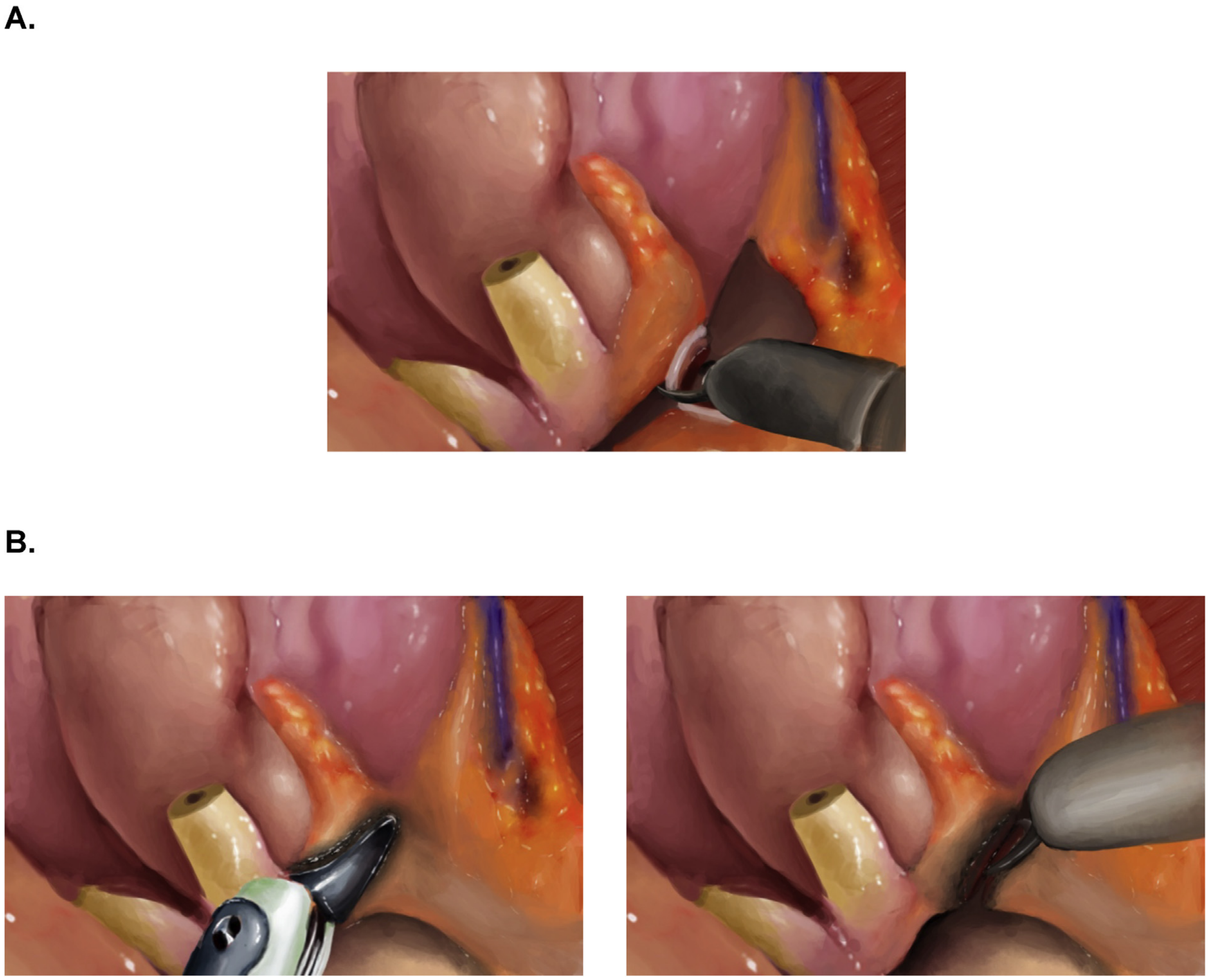


Fig. 2 – Illustration of the prostatic pedicle dissection with the (A) clips and (B) bipolar approach.

Maryland bipolar forceps on both the specimen and the stay side at the location where the clips would otherwise be placed. A short burst of bipolar energy is used to avoid the creation of char. Then, cold dissection is performed between the cauterized regions (Fig. 2B). Additionally, the vas deferens is cauterized with bipolar forceps and dissected with cold scissors, avoiding the use of surgical clips. Nerve-sparing status was defined as complete (bilateral intrafascial), partial (unilateral intrafascial or unilateral/bilateral interfascial), or none (bilateral extrafascial). Bilateral PLND was performed in men with intermediate- or high-risk disease based on the D'Amico classification [15].

2.3. Study variables and outcomes

Baseline demographic as well as pre- and postoperative clinicopathological characteristics were collected. Urinary as well as sexual function were assessed using the Expanded Prostate Cancer Index for Clinical Practice (EPIC-CP), with scores ranging from 0 to 12 and lower scores indicating better outcomes [16]. Patients were seen in the clinic postoperatively at 7–10 d for catheter removal, at 3 mo after operation, and at 6-mo intervals thereafter. These visits included evaluation of EPIC-CP scores and prostate-specific antigen (PSA). Complications that took place within 1 mo after surgery were classified according to the modified Clavien-Dindo system [17]. Continence was defined based on the EPIC-CP question regarding pad usage. Potency was defined as the ability to achieve and maintain erection adequate for sexual intercourse, with or without the use of phosphodiesterase type 5 (PDE5) inhibitors.

Our primary objective was to compare RARP-bi and RARP-c for differences in functional (potency and continence) as well as oncological outcomes. Our secondary endpoints were perioperative and complication outcomes of RARP-bi and RARP-c.

2.4. Statistical analysis

Independent variables were compared between RARP-c and RARP-bi using the paired *t* test for continuous variables and chi-square test for categorical variables. Categorical variables were reported as frequencies and proportions. Continuous variables were reported as mean ± standard deviation or as median and interquartile range. Furthermore, multivariable regression modeling was used to examine independent associations between approach (RARP-bi and RARP-c) and EPIC-CP urinary and sexual function scores among men who completed questionnaires at >1 yr following RARP. Patients with incomplete EPIC-CP urinary or sexual function scores after this time (12 mo) were censored from their corresponding follow-up endpoints. A multivariable model was also used to identify variables associated with positive surgical margins (PSMs). Covariates were included in the model a priori, independent of univariate p values. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) are shown. All statistical analyses were conducted using

Please cite this article in press as: Basourakos SP, et al. Clipless Robotic-assisted Radical Prostatectomy and Impact on Outcomes. Eur Urol Focus (2021), https://doi.org/10.1016/j.euf.2021.06.010

R version 1.3 (R Foundation for Statistical Computing, Vienna, Austria) with two-sided statistical significance achieved at alpha = 0.05.

3. Results

3.1. Patient characteristics

Patient demographics and preoperative disease characteristics for RARP-bi and RARP-c groups are shown in Table 1. RARP-bi and RARP-c groups included 144 and 194 men, respectively. There was no overall statistical difference between the two groups in terms of age (65 ± 8 vs 65 ± 7 yr, $p = 0.6$), body mass index (27.3 ± 3.9 vs 27.3 ± 3.4, $p = 0.9$), comorbidities (no comorbidities in 44.4% vs 52.1%, $p = 0.19$), as well as baseline PSA (10.2 ± 9.3 vs 8.6 ± 7.6, $p = 0.1$). There were more patients with clinical T2 and T3 disease in the RARP-bi group than in the RARP-c group (12% vs 4.6%, $p = 0.017$).

Table 1 – Preoperative patient demographics and clinical data

	RARP-bi (N = 144; 43%)	RARP-c (N = 194; 57%)	p value[a]
Age (yr), mean ± SD	65 ± 8	65 ± 7	0.6
BMI (kg/m^2), mean ± SD	27.3 ± 3.9	27.3 ± 4	0.9
Race, n (%)			0.4
White	95 (73)	125 (68)	
Asian	16 (12)	28 (15)	
African American	14 (11)	15 (8.2)	
Hispanic	6 (4.6)	16 (8.7)	
Other	13 (9)	10 (5.1)	
Comorbidities, n (%)			0.19
CAD	15 (10)	12 (6.2)	0.2
Hypertension	79 (55)	84 (43)	0.046
Diabetes	17 (11)	23 (12)	>0.9
CKD	3 (2.1)	4 (2.1)	>0.9
PSA (ng/ml), mean ± SD	10.2 ± 9.3	8.6 ± 7.6	0.1
Biopsy Gleason group, n (%)			0.13
1	20 (14)	34 (18)	
2	65 (45)	80 (41)	
3	32 (22)	36 (19)	
4	9 (6)	27 (14)	
5	18 (12)	7 (9)	
MRI PIRADS score, n (%)			0.12
3	26 (19)	38 (21)	
4	48 (35)	83 (45)	
5	62 (46)	64 (35)	
Clinical stage, n (%)			0.029
T1	126 (87.5)	184 (95)	
T2	17 (12)	9 (4.6)	
T3	1 (0.7)	1 (0.5)	
	RARP-bi (N = 87)[b]	RARP-c (N = 121)[b]	
EPIC-CP urinary incontinence score, mean ± SD	0.6 ± 1.1	0.9 ± 1.4	0.038
EPIC-CP sexual function score, mean ± SD	2.8 ± 2.9	3.2 ± 2.9	0.3

BMI = body mass index; CAD = coronary artery disease; CKD = chronic kidney disease; EPIC-CP = Expanded Prostate Cancer Index Composite for Clinical Practice; MRI = magnetic resonance imaging; PIRADS = Prostate Imaging Reporting and Data System; PSA = prostate-specific antigen; RARP = robotic-assisted radical prostatectomy; RARP-bi = RARP with the use of bipolar energy; RARP-c = RARP with the use of clips; SD = standard deviation.

[a] Statistical tests performed: Wilcoxon rank-sum test, chi-square test of independence, and Fisher's exact test.

[b] Patients with completed respective sections of the EPIC-CP questionnaire.

3.2. Perioperative outcomes

Table 2 demonstrates the perioperative outcomes. No patient required reoperation. The mean anesthesia and operative time were both shorter in the RARP-bi group (218 ± 32 vs 241 ± 31 min and 162 ± 29 vs 179 ± 29 min for the RARP-bi vs RARP-c group, respectively; $p < 0.001$ for both). The estimated blood loss (154 ± 32 vs 167 ± 44, $p < 0.001$) and length of stay (1.1 ± 0.37 vs 1.2 ± 0.68, $p = 0.008$) were statistically but not clinically different between the two groups. Men in the RARP-bi group underwent fewer nerve sparing procedures than those in the RARP-c group (92% vs 99%, $p = 0.005$). Furthermore, the overall 30-d complication rates (12% vs 16%, $p = 0.5$) and bladder neck contracture rates (2.1% vs 3.6%, $p = 0.5$) were similar between the two groups. All the complications were of Clavien-Dindo grade I–II. There was no difference in lymphocele complications (1.4% vs 0.52%, $p = 0.58$).

3.3. Oncological outcomes

Oncological outcomes are reported in Table 2. There were no significant differences in Gleason grade of the prostatectomy specimen ($p = 0.091$), pT stage ($p = 0.7$), or pN stage ($p = 0.7$) between the two groups. Moreover, the overall PSM rate was not different between the two groups (29.9% vs 22.2%, $p = 0.4$); however, there were more men who underwent RARP-c with focal positive margins (22.2% vs 11.8%, $p = 0.02$). Biochemical recurrence (BCR) rates (12.6% vs 14.7%, $p = 0.7$) and time to BCR (113 ± 66 vs 287 ± 288 d, $p = 0.2$) were not different between the two groups. On a multivariable logistic regression model for PSMs, RARP-bi was not associated with higher odds of PSMs (OR 1.04, 95% CI 0.6–1.8; $p = 0.9$; Table 3).

3.4. Functional and quality of life outcomes

While the RARP-c group had a worse baseline EPIC-CP urinary function score (0.6 ± 1.1 vs 0.9 ± 1.4, $p = 0.038$), there was no difference in baseline EPIC-CP urinary sexual function score (2.8 ± 2.9 vs 3.2 ± 2.9, $p = 0.3$; Table 1). No significant differences in EPIC-CP urinary or sexual function scores were observed at 3, 9, 15, and 18 mo postoperatively (Fig. 3). However, when we compared the overall and 12-mo continence with zero daily pads, men who underwent RARP-bi had significantly better outcomes than those who underwent RARP-c (68% vs 52%, $p = 0.005$, and 50% vs 38%, $p = 0.05$, respectively; Table 4). Furthermore, on a multivariable linear regression model for EPIC-CP urinary and sexual function scores, RARP-bi was not associated with the higher odds of a higher (worse) EPIC-CP score (parameter estimate 0.54, 95% CI 0.2–1.4, $p = 0.2$, and parameter estimate 0.35, 95% CI 0.08–1.54, $p = 0.2$, respectively; Tables 5 and 6).

Please cite this article in press as: Basourakos SP, et al. Clipless Robotic-assisted Radical Prostatectomy and Impact on Outcomes. Eur Urol Focus (2021), https://doi.org/10.1016/j.euf.2021.06.010

Table 2 – Peri- and postoperative outcomes

	RARP-bi (*N* = 144; 43%)	RARP-c (*N* = 194; 57%)	*p* value[a]
Anesthesia time (min), mean ± SD	218 ± 32	241 ± 31	<0.001
Surgery time (min), mean ± SD	162 ± 29	179 ± 29	<0.001
Nerve sparing, *n* (%)			<0.001
Full	106 (74)	177 (91)	
Partial	27 (19)	15 (7.7)	
None	11 (7.6)	2 (1.0)	
Any nerve sparing, *n* (%)	133 (92)	192 (99)	0.005
Complete nerve sparing, *n* (%)	106 (74)	177 (91)	<0.001
Estimated blood loss (ml), mean ± SD	154 ± 32	167 ± 44	<0.001
Length of stay (d), mean ± SD	1.1 ± 0.37	1.2 ± 0.68	0.008
Complication, *n* (%)	18 (12)	31 (16)	0.5
Complication per Clavien-Dindo grade, *n* (%)			0.08
I	8 (5.6)	20 (10)	
II	9 (6.2)	5 (2.6)	
Bladder neck contracture, *n* (%)	3 (2.1)	7 (3.6)	0.5
Gleason group, *n* (%)			0.09
1	14 (9.7)	26 (13.4)	
2	66 (45.8)	91 (46.9)	
3	34 (23.6)	37 (19.1)	
4	5 (3.3)	18 (9.3)	
5	25 (17.4)	22 (11.3)	
Prostate volume (mm), mean ± SD	57 ± 26	56 ± 24	0.9
Pathologic stage, *n* (%)			0.7
T2	64 (44.4)	94 (48.5)	
T3a	54 (37.5)	69 (35.6)	
T3b	26 (18.1)	31 (16.0)	
Lymph node involvement, *n* (%)	8 (5.7)	14 (7.2)	0.7
Positive margin, *n* (%)	43 (29.9)	49 (25.3)	0.4
Focal	17 (11.8)	43 (22.2)	0.02
Nonfocal	26 (18.1)	6 (3.1)	<0.001
Margin location, *n* (%)			0.05
Anterior	5 (14.7)	11 (25.0)	
Apex	9 (26.5)	3 (6.8)	
Bladder neck	5 (14.7)	3 (6.8)	
Posterior	15 (44.1)	27 (61.4)	
Biochemical recurrence, *n* (%)	18 (12.6)	27 (14.7)	0.7
Time to BCR (d), mean ± SD	113 ± 66	287 ± 288	0.2

BCR = biochemical recurrence; RARP = robotic-assisted radical prostatectomy; RARP-bi = RARP with the use of bipolar energy; RARP-c = RARP with the use of clips; SD = standard deviation.

[a] Statistical tests performed: Wilcoxon rank-sum test, chi-square test of independence, and Fisher's exact test.

4. Discussion

The goal of radical prostatectomy is to achieve the trifecta of cancer control/undetectable PSA and recovery of urinary and sexual function [18]. The principle of athermal nerve sparing is to avoid inadvertent damage to unmyelinated nerve fibers responsible for potency. Therefore, the absence of cautery in proximity to the NVB has become a “dogma” of nerve-sparing prostatectomy. Several techniques have been described for the control of the lateral prostatic pedicle

Table 3 – Multivariable logistic regression model for positive surgical margins

Characteristic	OR	95% CI	*p* value
Preoperative PSA	1.04	1.01, 1.07	0.023
Pathologic stage (Ref = T2)			
T3a	1.54	0.82, 2.92	0.2
T3b	4.21	1.92, 9.38	<0.001
Any nerve sparing (Ref = no nerve sparing)	0.33	0.08, 1.26	0.11
RARP-bi (Ref = RARP-c)	1.04	0.60, 1.80	0.9
Gleason grade (Ref = 1)			
2	0.69	0.28, 1.91	0.4
3	1.28	0.47, 3.77	0.6
4	0.91	0.24, 3.37	0.9
5	1.88	0.61, 6.19	0.3

CI = confidence interval; PSA = prostate-specific antigen; RARP = robotic-assisted radical prostatectomy; OR = odds ratio; RARP-bi = RARP with the use of bipolar energy; RARP-c = RARP with the use of clips; Ref = reference.

Please cite this article in press as: Basourakos SP, et al. Clipless Robotic-assisted Radical Prostatectomy and Impact on Outcomes. Eur Urol Focus (2021), https://doi.org/10.1016/j.euf.2021.06.010

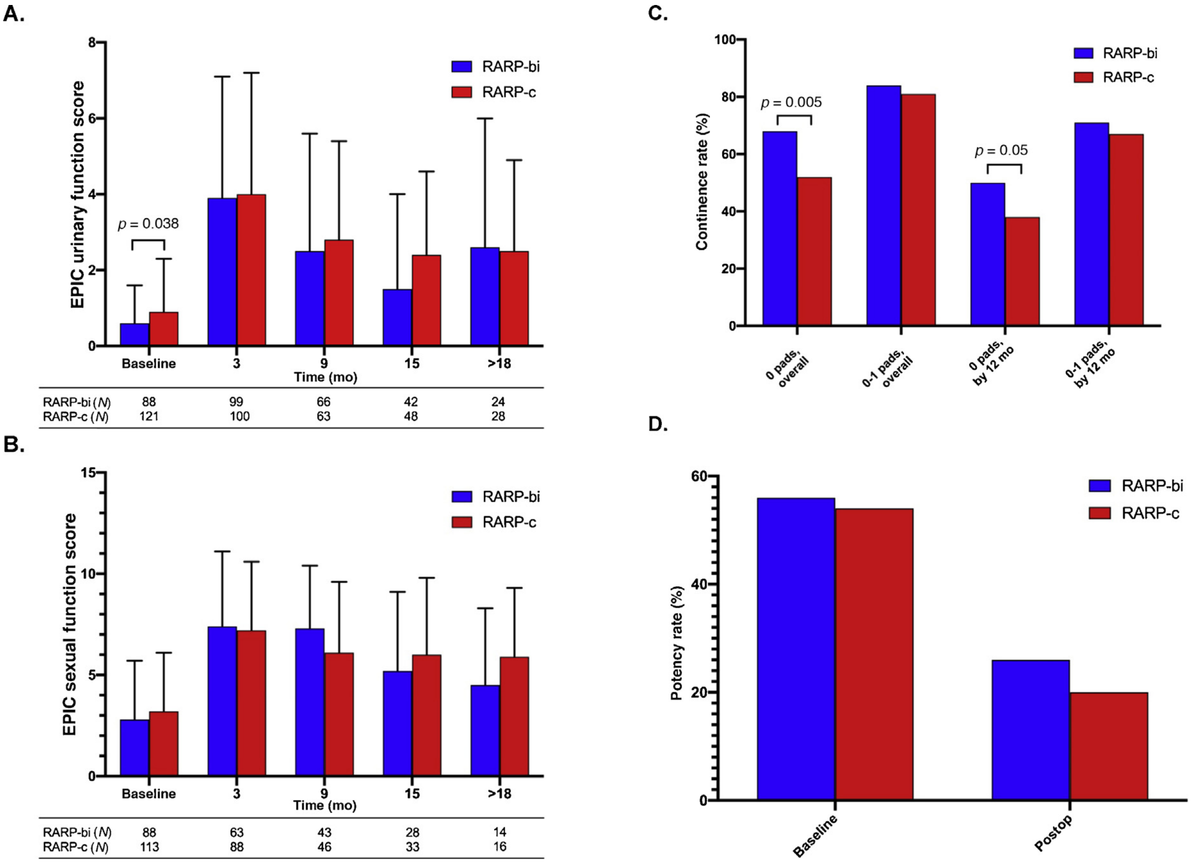


Fig. 3 – (A) EPIC-CP urinary function score and (B) EPIC-CP sexual function score between RARP-bi and RARP-c for men with completed questionnaires at a given follow-up time point throughout the study period. (C) Continence and (D) overall potency rates between RARP-bi and RARP-c for men with completed questionnaires at a given follow-up time point throughout the study period. Mean and standard deviation are demonstrated for each time point.

EPIC-CP = Expanded Prostate Cancer Index for Clinical Practice; RARP = robotic-assisted radical prostatectomy; RARP-bi = RARP with the use of bipolar energy; RARP-c = RARP with the use of clips.

dissection, including stapling, clips, etc. [4,5,19]. Herein, we challenge this dogma by using fine bipolar energy for clipless prostatic pedicle dissection.

The work of Ong et al [2] in 2004 established cautery as a threat to the NVB. The authors used a canine model and reported that the "use of hemostatic energy sources in proximity to the prostate during dissection of the neurovascular bundle is associated with a significantly decreased erectile response to cavernous nerve stimulation," likely as a consequence of thermal damage. It is unclear to what extent their experimental conditions recapitulate modern RARP, where robotic instruments and camera technology allow for fine dissection of the NVBs from their pedicle. Furthermore, findings from the study of Donzelli et al [20] in the field of otolaryngology suggest that bipolar cautery can be used safely in proximity to nerve tissue with the addition of irrigation. While no irrigation was used in our series, we believe that well-controlled and meticulous use of bipolar cautery as well as the distance of the pedicle from the NVB minimizes the effect of the thermal neuronal injury.

Our study has several important findings. First, functional outcomes do not differ between RARP-bi and RARP-c. We found no discrepancy in continence, potency, or other patient-reported outcomes between the two approaches. Small differences in baseline EPIC-CP urinary function score between the two groups were not clinically significant [21,22]. Nonetheless, a multivariable model adjusting for baseline differences between groups demonstrated no correlation between RARP-bi and EPIC-CP urinary and sexual function scores at 12 mo. Continence outcomes were superior in RARP-bi, although it is unclear whether this is a consequence of absent surgical clips, and no difference was seen on multivariable analysis. Bladder neck dissection and reconstruction technique did not change over the study period [23]. Notably, in terms of sexual function, we did not notice any difference between the two techniques, and our current results compare similarly to our previously published experience [12] as well as others in the literature [24,25].

Second, oncological outcomes do not appear to differ between techniques. Positive margin rates were comparable in both groups (29.9% for RARP-bi and 25.3% for RARP-c) and are consistent with the literature when accounting for disease stage (>50% with pT3 in our study) [26–28]. This likely reflects operating on more high-risk disease than reported in historical series as a consequence of recent

Table 4 – Continence and potency outcomes

Urinary continence	RARP-bi (*N* = 133)	RARP-c (*N* = 159)	*p* value[a]
Overall[b] continence, *n* (%)			
0 pads	91 (68)	82 (52)	0.005
0–1 safety pad	112 (84)	128 (81)	0.5
Continence by 12 mo[c], *n* (%)			
0 pads	67 (50)	61 (38)	0.05
0–1 safety pad	95 (71)	107 (67)	0.5
Time to continence (mo), median (IQR)			
0 pads	9.5 (3.6, 12.6)	9.5 (3.4, 12.2)	0.5
0–1 safety pad	3.8 (3.4, 9.6)	3.8 (3.3, 9.9)	0.8
Potency	**RARP-bi (*N* = 87)**	**RARP-c (*N* = 109)**	***p* value[a]**
Baseline potency, *n* (%)	49 (56)	59 (54)	0.9
Postoperative potency, *n* (%)	24 (28)	28 (27)	0.6
Time to potency (mo), median (IQR)	12.4 (4–17)	9.3 (3.4–13.6)	0.8

IQR = interquartile range; RARP = robotic-assisted radical prostatectomy; RARP-bi = RARP with the use of bipolar energy; RARP-c = RARP with the use of clips.

[a] Statistical tests performed: Wilcoxon rank-sum test, chi-square test of independence, and Fisher's exact test.

[b] Any report of continence at follow-up visit overall.

[c] Any report of continence at follow-up visit before 12 mo.

Table 5 – Multivariable linear regression model for EPIC-CP urinary function score at >12 mo of follow-up

Characteristic	Parameter estimate	95% CI	*p* value
Age (1 yr increment)	1.00	0.93, 1.06	0.9
BMI (kg/m^2)	1.03	0.92, 1.16	0.6
Complete nerve sparing (Ref = no nerve sparing)	0.45	0.10, 2.06	0.3
Clinical stage $\geq$ T2 (Ref = T1)	0.22	0.03, 1.70	0.2
RARP-bi (Ref = RARP-c)	0.54	0.20, 1.40	0.2
Baseline EPIC-CP urinary incontinence score	1.47	0.98, 2.18	0.063

BMI = body mass index; CI = confidence interval; EPIC-CP = Expanded Prostate Cancer Index Composite for Clinical Practice; RARP = robotic-assisted radical prostatectomy; RARP-bi = RARP with the use of bipolar energy; RARP-c = RARP with the use of clips; Ref = reference.

Table 6 – Multivariable linear regression model for EPIC-CP sexual function score at >12 mo of follow-up

Characteristic	Parameter estimate	95% CI	*p* value
Age (1 yr increment)	1.26	1.14, 1.39	<0.001
BMI (kg/m^2)	1.12	0.94, 1.34	0.2
Complete nerve sparing (Ref = no nerve sparing)	0.81	0.10, 6.32	0.8
Clinical stage $\geq$T2 (Ref = T1)	4.11	0.15, 116	0.4
RARP-bi (Ref = RARP-c)	0.35	0.08, 1.54	0.2
Baseline EPIC sexual function score	1.51	1.13, 2.01	0.007

BMI = body mass index; CI = confidence interval; EPIC-CP = Expanded Prostate Cancer Index Composite for Clinical Practice; RARP = robotic-assisted radical prostatectomy; RARP-bi = RARP with the use of bipolar energy; Ref = reference.

trends in prostate cancer screening and decreased radical prostatectomy rates for low-risk disease. Additionally, our BCR rates are similar to those reported in the literature [26]. Time to BCR did not differ between groups, and the apparent discrepancy in range is a consequence of longer follow-up among RARP-c patients, who had surgery earlier within the date range of our study.

To the best of our knowledge, this technique of clipless bipolar pedicle control has not been described previously. A similar technique was described by Chien and colleagues [29] in a series of 56 patients. In these series, prostatic pedicles were athermally mobilized and swept off the prostate; bipolar cautery was used only for small vessel sealing, in contrast to our study. Although the authors reported PSMs in only 10% of the patients, we speculate that this low rate might be related to the prevalence of low-stage disease (80% of men had T2 disease) in the study population. Furthermore, the authors report an overall potency rate of 69% at 12 mo, which is slightly higher than what we observed. However, baseline patient characteristics differ from our study, and only six men were followed up until 12 mo in this study as compared with 87 in ours. Guimaraes et al [30] also performed a study that compared standard transperitoneal RARP with extraperitoneal RARP in conjunction with clipless pedicle dissection and use of bipolar cautery. Similar to our study, the authors did not

Please cite this article in press as: Basourakos SP, et al. Clipless Robotic-assisted Radical Prostatectomy and Impact on Outcomes. Eur Urol Focus (2021), https://doi.org/10.1016/j.euf.2021.06.010

notice any difference in continence between the clip and bipolar groups. The return to potency rate at 12 mo was 75% for the bipolar group. Finally, the overall PSM rate in the bipolar group in this series was 26% and similar to our study. Both studies found potency rates to be better with the clipless procedure; however, we did not observe any differences. The latter could be explained by the fact that these modifications were made later in the adoption of robotic surgery for radical prostatectomy and later in the operative experience of the surgeon. Finally, we did not use any clips throughout the procedure, including the PLND. We did not observe differences in complications, including lymphocele formation, consistent with a recent randomized controlled trial [9].

Given similar oncological and functional outcomes, shorter anesthesia and operative time, as well as less dependence on the bedside assistant for clip placement are particular advantages of RARP-bi versus RARP-c. In our series, the role of the bedside assistant was limited to suction and needle exchange. Garbens et al [31] recently examined the role of bedside assistant's experience in a prostatectomy cohort. The authors demonstrated that the experience of the bedside assistant is related to better operative outcomes such as blood loss and PSMs. In a similar study, Cimen et al [32] showed that assistant inexperience is associated with longer operative time. These results highlight a substantial impact on the outcomes of bedside assistant quality, which may be a challenging variable to control in routine practice. Therefore, independence from bedside assistance may enhance consistency of outcome.

While a complete cost effectiveness analysis of RARP-bi is beyond the scope of this study and was not performed, we believe that the clipless approach decreases cost as a consequence of shorter operative time and use of fewer instruments. As interest in value-based care grows, techniques with equivalent outcomes and reduced costs become increasingly attractive. Operative time in particular is expensive and every additional minute of general anesthesia can cost up to several hundreds of dollars, depending on the materials used and opportunity cost of performing fewer operations [33]. Here, we demonstrate noninferior oncological and functional outcomes along with shorter operative time using a novel approach of fine bipolar dissection of NVBs and clipless PLND.

Despite its strengths, our study has limitations. First, this is a retrospective single-surgeon study and is subject to biases inherent to the study design compared with a randomized controlled trial. Results of an experienced single surgeon may not be generalized to lower-volume providers, although the number of well-trained and skilled robotic surgeons has increased over time. Second, the delicate use of bipolar cautery did not result in thermal artifacts that challenged the margin evaluation by our pathology team. However, we acknowledge that thermal artifacts could affect the interpretation of margins by nonexperienced genitourinary pathologists. Third, our study lacks long-term follow-up of BCR outcomes. Finally, we acknowledge that more prospective studies are needed to confirm our findings.

5. Conclusions

The use of bipolar energy in proximity to the NVB breaks from the dogma of no energy during nerve-sparing. In this single-surgeon series, we retrospectively compared the dissection of the lateral prostatic pedicle and PLND with biopolar energy versus the standard approach with clips. We did not find any difference in functional or oncological outcomes. However, prospective studies are needed to validate our findings.

Author contributions: Spyridon P. Basourakos 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: Basourakos, Lewicki, Ramaswamy, Cheng, Dudley, Yu, Karir, Khani, Hu.
Analysis and interpretation of data: Basourakos, Lewicki, Ramaswamy, Yu, Karir, Hung, Khani, Hu.
Drafting of the manuscript: Basourakos, Lewicki, Hu.
Critical revision of the manuscript for important intellectual content: Basourakos, Lewicki, Hung, Hu.
Statistical analysis: Lewicki, Ramaswamy, Basourakos.
Obtaining funding: Hu.
Administrative, technical, or material support: Hu.
Supervision: Hu.
Other: None.

Financial disclosures: Spyridon P. Basourakos certifies that all conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript (eg, employment/affiliation, grants or funding, consultancies, honoraria, stock ownership or options, expert testimony, royalties, or patents filed, received, or pending), are the following: None.

Funding/Support and role of the sponsor: Jim C. Hu receives research support from the Frederick J. and Theresa Dow Wallace Fund of the New York Community Trust. Jim C. Hu also receives salary support from NIHR01 CA241758, PCORICER-2019C1-15682, CER-2019C2-17372 and the Prostate Cancer Foundation.

Appendix A. Supplementary data

The Surgery in Motion video accompanying this article can be found in the online version at doi:https://doi.org/10.1016/j.euf.2021.06.010 and via www.europeanurology.com.

References

[1] Walsh PC. Anatomic radical prostatectomy: evolution of the surgical technique. J Urol 1998;160:2418–24.
[2] Ong AM, Su LM, Varkarakis I, et al. Nerve sparing radical prostatectomy: effects of hemostatic energy sources on the recovery of cavernous nerve function in a canine model. J Urol 2004;172:1318–22.

[3] Hefermehl LJ, Largo RA, Hermanns T, Poyet C, Sulser T, Eberli D. Lateral temperature spread of monopolar, bipolar and ultrasonic instruments for robot-assisted laparoscopic surgery. BJU Int 2014;114:245–52.

[4] Wit EM, De Jong J, Acar C, et al. Stapling for prostate pedicle management during robot-assisted radical prostatectomy. Minerva Urol Nefrol 2016;68:429–36.

[5] Gill IS, Ukimura O, Rubinstein M, et al. Lateral pedicle control during laparoscopic radical prostatectomy: refined technique. Urology 2005;65:23–7.

[6] Tavukcu HH, Aytac O, Atug F. Nerve-sparing techniques and results in robot-assisted radical prostatectomy. Investig Clin Urol 2016;57: S172–84.

[7] Blumenthal KB, Sutherland DE, Wagner KR, Frazier HA, Engel JD. Bladder neck contractures related to the use of Hem-o-lok clips in robot-assisted laparoscopic radical prostatectomy. Urology 2008;72:158–61.

[8] Yu CC, Yang CK, Ou YC. Three types of intravesical Hem-o-Lok clip migration after laparoscopic radical prostatectomy. J Laparoendosc Adv Surg Tech A 2015;25:1005–8.

[9] Grande P, Di Pierro GB, Mordasini L, et al. Prospective randomized trial comparing titanium clips to bipolar coagulation in sealing lymphatic vessels during pelvic lymph node dissection at the time of robot-assisted radical prostatectomy. Eur Urol 2017;71:155–8.

[10] Zohar Y, Sadov R, Strauss M, Djialdetti M. Ultrastructural study of peripheral nerve injury induced by monopolar and bipolar diathermy. Ann Otol Rhinol Laryngol 1996;105:673–7.

[11] Schietroma JJ, Tenzel RR. The effects of cautery on the optic nerve. Ophthalmic Plast Reconstr Surg 1990;6:102–7.

[12] Alemozaffar M, Duclos A, Hevelone ND, et al. Technical refinement and learning curve for attenuating neurapraxia during robotic-assisted radical prostatectomy to improve sexual function. Eur Urol 2012;61:1222–8.

[13] Kowalczyk KJ, Huang AC, Hevelone ND, et al. Stepwise approach for nerve sparing without countertraction during robot-assisted radical prostatectomy: technique and outcomes. Eur Urol 2011;60:536–47.

[14] Kowalczyk KJ, Huang AC, Hevelone ND, et al. Effect of minimizing tension during robotic-assisted laparoscopic radical prostatectomy on urinary function recovery. World J Urol 2013;31:515–21.

[15] Touijer KA, Sjoberg DD, Benfante N, et al. Limited versus extended pelvic lymph node dissection for prostate cancer: a randomized clinical trial. Eur Urol Oncol 2021. http://dx.doi.org/10.1016/j.euo.2021.03.006, S2588-9311(21)00050-X. Epub ahead of print. PMID: 33865797.

[16] Chang P, Szymanski KM, Dunn RL, et al. Expanded prostate cancer index composite for clinical practice: development and validation of a practical health related quality of life instrument for use in the routine clinical care of patients with prostate cancer. J Urol 2011;186:865–72.

[17] Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 2004;240:205–13.

[18] Eastham JA, Scardino PT, Kattan MW. Predicting an optimal outcome after radical prostatectomy: the trifecta nomogram. J Urol 2008;179:2207–10, discussion 2210–2211.

[19] Beck SM, Skarecky D, Miller S, Ahlering TE. Athermal tension adjustable suture ligation of the vascular pedicle during robot-assisted prostatectomy. J Endourol 2012;26:834–7.

[20] Donzelli J, Leonetti JP, Wurster RD, Lee JM, Young MR. Neuroprotection due to irrigation during bipolar cautery. Arch Otolaryngol Head Neck Surg 2000;126:149–53.

[21] Chipman JJ, Sanda MG, Dunn RL, et al. Measuring and predicting prostate cancer related quality of life changes using EPIC for clinical practice. J Urol 2014;191:638–45.

[22] Skolarus TA, Dunn RL, Sanda MG, et al. Minimally important difference for the Expanded Prostate Cancer Index Composite Short Form. Urology 2015;85:101–5.

[23] Freire MP, Weinberg AC, Lei Y, et al. Anatomic bladder neck preservation during robotic-assisted laparoscopic radical prostatectomy: description of technique and outcomes. Eur Urol 2009;56:972–80.

[24] Menon M, Shrivastava A, Kaul S, et al. Vattikuti Institute prostatectomy: contemporary technique and analysis of results. Eur Urol 2007;51:648–57, discussion 657–658.

[25] Shikanov S, Woo J, Al-Ahmadie H, et al. Extrafascial versus interfascial nerve-sparing technique for robotic-assisted laparoscopic prostatectomy: comparison of functional outcomes and positive surgical margins characteristics. Urology 2009;74:611–6.

[26] Mottrie A, De Naeyer G, Novara G, Ficarra V. Robotic radical prostatectomy: a critical analysis of the impact on cancer control. Curr Opin Urol 2011;21:179–84.

[27] Yossepowitch O, Briganti A, Eastham JA, et al. Positive surgical margins after radical prostatectomy: a systematic review and contemporary update. Eur Urol 2014;65:303–13.

[28] Covas Moschovas M, Bhat S, Onol FF, et al. Modified apical dissection and lateral prostatic fascia preservation improves early post-operative functional recovery in robotic-assisted laparoscopic radical prostatectomy: results from a propensity score-matched analysis. Eur Urol 2020;78:875–84.

[29] Chien GW, Mikhail AA, Orvieto MA, et al. Modified clipless antegrade nerve preservation in robotic-assisted laparoscopic radical prostatectomy with validated sexual function evaluation. Urology 2005;66:419–23.

[30] Guimaraes GC, Oliveira RAR, Santana TBM, et al. Comparative analysis of functional outcomes between two different techniques after 1088 robotic-assisted radical prostatectomies in a high-volume cancer center: a clipless approach. J Endourol 2019;33:1017–24.

[31] Garbens A, Lay AH, Steinberg RL, Gahan JC. Experienced bedside-assistants improve operative outcomes for surgeons early in their learning curve for robot assisted laparoscopic radical prostatectomy. J Robot Surg. In press. https://doi.org/10.1007/s11701-020-01146-8.

[32] Cimen HI, Atik YT, Altinova S, Adsan O, Balbay MD. Does the experience of the bedside assistant effect the results of robotic surgeons in the learning curve of robot assisted radical prostatectomy? Int Braz J Urol 2019;45:54–60.

[33] Macario A. What does one minute of operating room time cost? J Clin Anesth 2010;22:233–6.