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ORIGINAL ARTICLE

Transvesical versus extraperitoneal single-port robotic radical prostatectomy: a matched-pair analysis

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Abstract

Objective To compare our initial perioperative and postoperative outcomes of the single-port (SP) transvesical radical prostatectomy (TVRP) approach with the single-port extraperitoneal radical prostatectomy (ERP) approach.

Materials and methods Initial consecutive seventy-eight patients underwent SP TVRP between December 2020 and October 2021. Patients with extensive previous abdominal surgeries, or low- to intermediate-risk prostate cancer were selected. Data of consecutive 169 patients treated with SP ERP between February 2019 and November 2020, were used for comparison. Optimal matched-paired analysis of PSA value, biopsy Gleason score, and prostate volume was performed. Preoperative, perioperative, and early functional outcomes were included in the analysis. The median follow-up was 7 months and 9 months for TVRP and ERP groups respectively.

Results The median total operative time was longer in the TVRP compared to the ERP group ($p = .002$). There were no differences in intraoperative complications or surgical margin status. TVRP group had less rate of grade 3a Clavien–Dindo complications ($p = .026$). The Foley catheter duration was 3 (3, 4) days in the TVRP group compared to 7 (7, 8) days in the ERP group ($p < .001$). There was a consistently improved continence rate in the TVRP group at 6 weeks (72% TVRP, 48% ERP, $p = .004$), 3 months (97% TVRP, 81% ERP, $p = .008$), and 6 months postoperatively (100% TVRP, 93% ERP, $p = .047$). There was no difference in biochemical recurrence at 6 months of follow-up.

Conclusion In our initial series, TVRP allows for a faster continence recovery, without other functional or oncological compromises.

Keywords Prostate cancer · Prostatectomy · Robotic-assisted surgery · Laparoscopic surgery · Urologic surgical procedures

Abbreviations

RP	Radical prostatectomy
SP	Single-port
ERP	Extraperitoneal radical prostatectomy
TVRP	Transvesical radical prostatectomy
LND	Lymph node dissection
BMI	Body mass index
ASA	American society of anesthesiologists
IQR	Interquartile range

Introduction

Robotic radical prostatectomy (RP) has gained popularity in the United States and has become the most common approach for surgical management of prostate cancer [1]. The traditional robotic approach is a transperitoneal technique that may be associated with postoperative ileus and rare injury to intraperitoneal organs [2]. Extraperitoneal radical prostatectomy was described to address these concerns [3]. A limitation of the extraperitoneal approach, however, is limited working space for the multi-arm surgical platform and ultimately the technique did not gain widespread popularity.

In 2020, Zhou et al. published the first clinical series of transvesical RP using the da Vinci Si/Xi surgical platforms ((Intuitive Surgical, Sunnyvale, CA, USA), with a high rate of patients with immediate continence rate [4]. The same group compared this approach to the standard multiport transperitoneal RP, with a significantly higher continence

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rate, shorter Foley catheter duration, and similar sexual preservation and oncological outcomes [5]. Limitations of this transvesical approach using the multiport robot platform, however, are the instruments clashing and the big cystotomy incision required to accommodate the robotic instruments.

In 2018, the United States Food and Drug Administration approved the use of a purpose-built single-port (SP) robotic platform to perform radical prostatectomy. This SP surgical platform is designed to operate in small spaces through a single incision, which makes it an optimal system to perform extraperitoneal surgery. Kaouk et al. described a novel technique to perform single-port extraperitoneal radical prostatectomy (ERP) (Fig. 1) [6]. Compared to the traditional transperitoneal approach, ERP helped decrease morbidity, enhance postoperative recovery and decrease the need for narcotics postoperatively [7].

To further take advantage of the SP platform, we developed the single-port transvesical radical prostatectomy (TVRP) (Fig. 2) [8]. TVRP is a novel extraperitoneal approach to perform RP, which does not require creating a working space in the Retzius space, and offers promising perioperative outcomes and early return of continence [8]. In this study, we aimed to analyze the benefits of TVRP by comparing the early results to the ERP.

Materials and methods

Data source

From an institutional review board-approved, we have identified all consecutive 169 patients who underwent SP ERP between February 2019 and November 2020. Similarly, all 78 patients who underwent SP TVRP from December 2020 and October 2021 were identified. All patients had complete preoperative, perioperative, and early postoperative data available. TVRP procedure was described in details in our prior study [8]. Due to the baseline differences, a 1:1 optimal matched-pair analysis for preoperative PSA value, biopsy Gleason score, and prostate volume was performed for the final analysis.

Patient selection

In our practice, TVRP was offered to all intermediate-risk prostate cancer patients and low-risk patients with a significant family history of prostate cancer, or high-risk patients with suspected hostile peritoneal and/or extraperitoneal space due to extensive surgical history. ERP was offered to all patients with localized prostate cancer prior to the introduction of the TVRP approach. All patients were informed

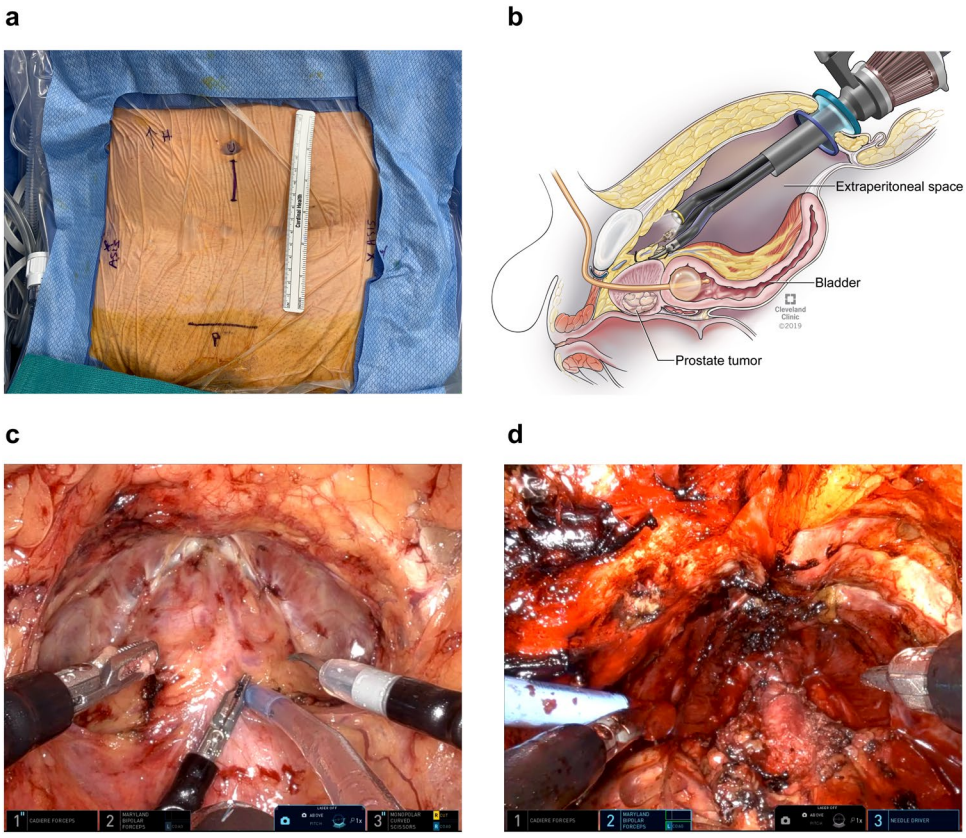

Fig. 1 The ERP approach. **A** Intraoperative photography of patient's incision marking. A 3 cm midline incision is made one fingerbreadth below the umbilicus. *H* Head. *U* Umbilicus. *P* Pelvic bone. *ASIS* Anterior superior iliac spine. **B** Illustration of the SP docking through the anterior rectus sheath to the arcuate line and the retroperitoneal space in ERP. **C** Intraoperative scope view. Note that the balloon dissector has created the extraperitoneal space. **D** Differential Visualization of Vesicourethral anastomosis using a 3–0 V-loc suture on RB-1 needle

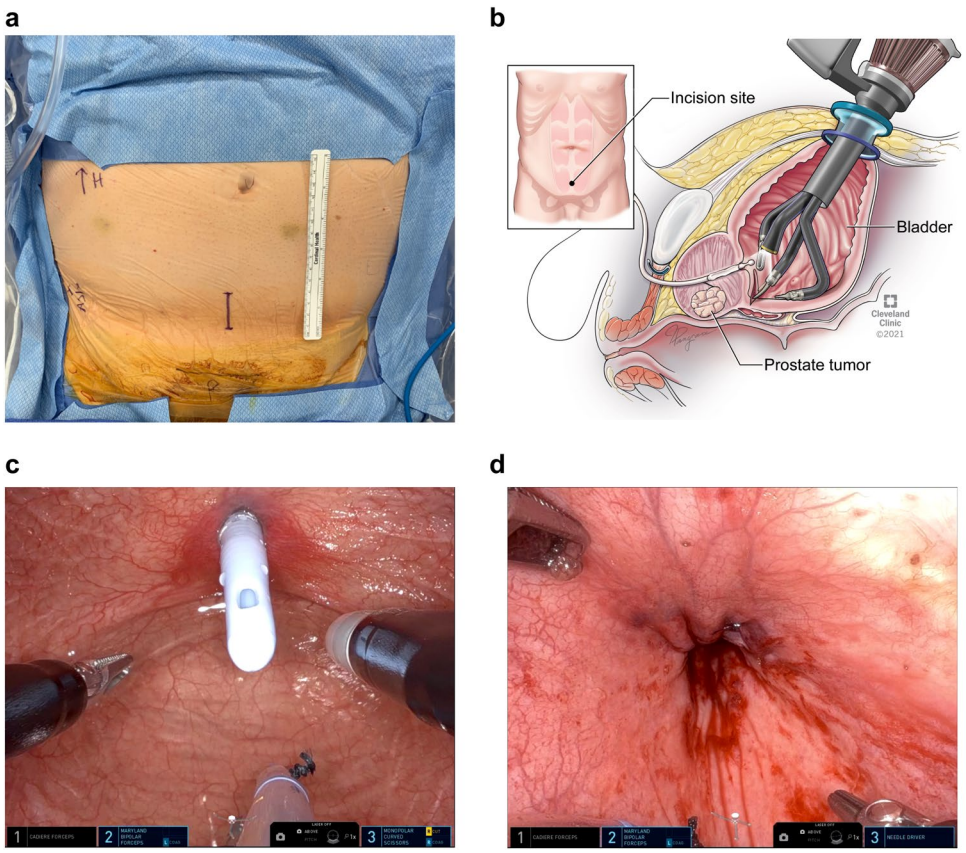

Fig. 2 The TVRP approach. **A** Intraoperative photography of patient's incision marking. A 3 cm midline incision is made one fingerbreadth above the pubic bone. *H* Head. *P* Pelvic bone. *ASIS* Anterior superior iliac spine. **B** Illustration of the percutaneous access of the SP robot into the bladder. **C** Intraoperative scope view of the bladder just before starting incision. Note the bladder trigone and the ROSI (Remotely Operated Suction Irrigation, Vascular Technology Inc, Nashua, NH) flexible suction tubing. The bladder is insufflated up to 12 mmHg. (Differential Visualization of Vesicourethral anastomosis using a 3–0 V-loc suture on RB-1 needle

and consented on the steps of the procedure. For the initial 18 cases, TVRP was only offered to patients without indications for lymph node dissection (LND). After case 19, TVRP and LND were offered to intermediate-risk patients with over 7% probability of lymph node metastasis according to the Briganti nomogram [9].

Variables

Preoperative variables were recorded including age, gender, race, body mass index (BMI), American society of anesthesiology score (ASA), prostate-specific antigen (PSA), prostate volume, biopsy Gleason score, sexual health index for men (SHIM) [10], and prostate imaging reporting and data system (PI-RADS) score v2.1 for patients with available preoperative multiparametric magnetic resonance imaging (MRI) [11]. Perioperative variables included operative time, estimated blood loss (EBL), hospital length of stay, pain score at discharge, surgical margins, complication rate as defined by Clavien–Dindo classification [12], readmission rate, transfusion rate, readmission rate (within the 30 days after surgery). Postoperative variables included continence rate, numbers of daily pads used, PSA level, biochemical recurrence (BCR), and SHIM score at 6 weeks, 3 months, and 6 months after the surgery. The primary endpoint was postoperative continence rate, defined as requiring 0 or 1 protective pad per day. Secondary endpoints include retention post-Foley catheter removal, complication rate, length of hospitalization calculated from the time of surgery end to patient discharge from the hospital, and oncologic outcomes.

Statistical analyses

An optimal matched-paired analysis for preoperative PSA value, biopsy Gleason score, and prostate volume was performed with a 1:1 ratio. After matching, baseline characteristics were all comparable between the two groups (Table 1). Descriptive statistics for the ERP and TVRP groups were obtained by reporting median and interquartile range (IQR) for continuous variables, while frequencies and proportions for categorical variables, as appropriate. Continuous variables were analyzed with the Wilcoxon signed-rank test. Differences between categorical variables were assessed using chi-square and Fisher's exact tests, when appropriate. Statistical analyses were performed using the open-source R statistical software v.3.4.0 (R Foundation for Statistical Computing, Vienna, Austria). All tests were two-sided, with a significance set at $p < 0.05$.

Table 1 Post-matching baseline characteristics of 78 patients who underwent ERP and 78 patients who underwent TVRP

Baseline characteristics	ERP ($N=78$)	TVRP ($N=78$)	p value
Age, years			0.796
Median (Q1, Q3)	62.5 (58.1, 67.1)	61.5 (58.4, 66.2)	
BMI, kg/m^2			0.275
Median (Q1, Q3)	27.4 (25.5, 30.5)	28.3 (25.5, 31.3)	
Race, *N* (%)			0.446
African American	7.0 (9.0%)	3.0 (3.8%)	
Asian	1.0 (1.3%)	0.0 (0.0%)	
Caucasian	69.0 (88.5%)	73.0 (93.6%)	
Hispanic	0.0 (0.0%)	1.0 (1.3%)	
Other	1.0 (1.3%)	1.0 (1.3%)	
CCI, *N* (%)			0.702
2–3	27.0 (34.6%)	27.0 (34.6%)	
4–5	47.0 (60.3%)	49.0 (62.8%)	
> 6	4.0 (5.1%)	2.0 (2.6%)	
Preoperative PSA, ng/ml			0.769
Median (Q1, Q3)	5.5 (4.3, 7.8)	5.9 (4.3, 8.2)	
Preoperative SHIM score ≥ 17, *N* (%)			0.117
SHIM score ≥ 17	46.0 (64.8%)	39.0 (52.0%)	
SHIM score < 17	25.0 (35.2%)	36.0 (48.0%)	
Prostate volume, cc			0.910
Median (Q1, Q3)	30.0 (25.0, 45.7)	33.0 (25.8, 42.2)	
Biopsy Gleason score, *N* (%)			0.751
6	15.0 (19.5%)	24.0 (31.2%)	
7(3 + 4)	50.0 (64.9%)	35.0 (45.5%)	
7(4 + 3)	10.0 (13.0%)	15.0 (19.5%)	
8	1.0 (1.3%)	3.0 (3.9%)	
9(5 + 4)	1.0 (1.3%)	0.0 (0.0%)	
NCCN			0.773
Low risk	15.0 (20.0%)	20.0 (26.0%)	
Favorable intermediate risk	39.0 (52.0%)	38.0 (49.4%)	
Unfavorable intermediate risk	18.0 (24.0%)	15.0 (19.5%)	
High risk	3.0 (4.0%)	4.0 (5.2%)	
Previous abdominal surgery, *N* (%)	27.0 (34.6%)	37.0 (47.4%)	0.104
Advanced abdominal Surgeries, *N* (%)	1(1.3%)	11 (14.1)	**0.003**

BMI Body mass index, *CCI* Charlson comorbidity index, *PSA* Prostate specific antigen, *SHIM* Sexual health inventory for men, *NCCN* National comprehensive cancer network

Bold values are statistically significant

SP TVRP surgical technique

Through a 3 cm suprapubic midline incision, two finger-breadths above the pubic symphysis, the bladder was identified and entered. The new da Vinci SP access port (Intuitive Surgical, California, United States) was used for direct access. Through the access port, the dedicated multichannel port, an 8 mm Airseal port (Conmed Linvatec, Largo, Florida, USA), and the remotely operated suction irrigation system device (Vascular Technology, Nashua, NH, USA) were introduced. The surgical steps for transvesical radical prostatectomy were performed in the following order. (1) Posterior bladder neck dissection, (2) Vas deferens and seminal vesicle dissection, (3) Posterior dissection, (4) Anterior bladder neck and prostate dissection, (5) Pedicle and neurovascular bundle dissection, (6) Limited lymph node dissection, (7) Posterior Reconstruction and Urethrovesical Anostomosis, (8) removal of the prostate through a single incision and bladder closure. Limited lymph node dissection was performed for patients with > 7% risk of lymph node involvement calculated using Briganti nomogram [9].

Results

Study population

After matching, both ERP and TVRP groups were comparable in terms of baseline characteristics. While the rate of previous abdominal surgery was comparable, the TVRP group had a higher rate of advanced abdominal surgeries, such as colectomy, J-pouch, and kidney transplantation ($p = 0.003$) (Table 1).

Perioperative results

Perioperative results are presented in Table 2. The median skin-to-skin total operative time (IQR) was longer in the TVRP compared to the ERP group [210 (186, 236) vs 190 (171, 209) minutes, $p = 0.002$], with less EBL (IQR) in the TVRP group [100 (50, 150) vs 150 (100, 200 cc, $p = 0.002$)]. The rate of patients who underwent lymph node dissection was lower in the TVRP (45% vs 97%, $p < 0.001$) with no difference in the median lymph node yield (4 vs 5, $p = 0.917$). Both groups had minimal to no pain at discharge with a median hospital stay of 4–5 h. The Median (IQR) Foley catheter period was 3 (3, 4) days in the TVRP group compared to 7 (7, 8) days in the ERP group ($p < 0.001$), with no difference in the rate of urinary retention after catheter removal. There were no differences in intraoperative or postoperative complications between the two groups, however, ERP group had higher Clavien grade 3a complications, most commonly lymphocele that necessitated drainage.

Oncological and functional results

The median (IQR) follow-up period was 7 (4, 9) months and 9 (4, 12) months for TVRP and ERP, respectively. The positive surgical margin rate was comparable between the two groups (15.4% TVRP vs 25.6% ERP, $p = 0.113$). Postoperatively, the continence rate was consistently higher in the TVRP group with 72%, 97%, and 100% compared to 48%, 81%, and 93%, at 6 weeks ($p = 0.004$), 3 months ($p = 0.008$), and 6 months ($p = 0.047$) postoperative follow-up, respectively. There was no difference in the BCR rate between the two groups, (2.5% TVRP vs 4.0% ERP, $p = 0.862$) within 6 months after surgery. After excluding all patients with preoperative erectile dysfunction or with a non-nerve sparing approach, there was no difference in postoperative SHIM score at 3 (SHIM ≥ 17: 20% in TVRP vs 6.2% ERP, $p = 0.264$) and 6 (SHIM ≥ 17: 28.6% in TVRP vs 16.1% ERP, $p = 0.616$) months.

Discussion

This is the first study in the literature comparing single-port TVRP with ERP. TVRP resulted in an improved early continence rate at 6 weeks of follow-up (72% vs. 48%, $p = 0.004$). In both groups, the median length of postoperative hospital stay was 4.6–5.5 h, with approximately 63% of patients discharged on the day of surgery.

The median operative time was longer in the TVRP group (210 vs 190 min, $p = 0.002$). The limited anatomical working space associated with the transvesical approach creates challenges, which may explain longer operative times in the TVRP group. Moreover, the TVRP approach is in its infancy and necessitates a learning curve, translating into possible longer total operative time. As we gain experience, the difference in operative time may shorten, which will be the focus of future studies.

Moreover, patients with extensive previous abdominal surgery and hostile abdomen, such as proctectomy, J-Pouch, colostomy, reversal of colostomy, and kidney transplantation, who are otherwise not candidates for ERP or another transperitoneal approach, are now offered TVRP. This adds an advantage to the TVRP approach in expanding the alternative approaches for robot-assisted radical prostatectomy.

Our results, despite the short follow-up, are in concordance with the literature. Den et al. retrospectively performed a matched-pair comparison between their transvesical approach and standard transperitoneal multiport prostatectomy. The continence rate was higher in the transvesical group to reach 100% by 3 months, with no oncologic or sexual function differences in a follow-up of 12 months' duration. There are other techniques reported in the literature with the same fundamental principles, such as the Retzius-sparing RP [13] and the hood technique. [14] Both techniques result in an improved continence rate that is mainly contributed to the preservation of the integrity of the Retzius space and the recto-vesical pouch [13, 14]. The benefits of a single-port transvesical approach to the others, however, are the avoidance of using the transperitoneal space, a single abdominal incision, same-day hospital discharge, minimal postoperative pain, and fewer opioid requirements, and the fact that tumor location or prostate shape/size do not cause any contraindication [7, 15–17]. With SP-TVRP, a significant limitation is the extended lymph node dissection as we have only performed limited lymph node dissections [8]. The extent of lymph node dissection is still an area of controversy, and a recent clinical trial did not find a difference in the rate of biochemical recurrence of prostate cancer between limited and extended lymph node dissection [18]. In this study, to minimize this bias, we performed an optimal matched-pair analysis and excluded high-risk patients from the ERP cohort. Even though the number of lymph nodes

Table 2 Post-matching perioperative and postoperative outcomes of 78 patients who underwent ERP vs 78 patients who underwent TVRP

Perioperative & postoperative outcomes	ERP ($N=78$)	TVRP ($N=78$)	p value
Total operative time, min			**0.002**
Median (Q1, Q3)	190.0 (171.0, 209.0)	210.0 (186.0, 236.0)	
Estimated blood loss, cc			**0.002**
Median (Q1, Q3)	150.0 (100.0, 200.0)	100.0 (50.0, 150.0)	
Lymphadenectomy, *N* (%)	76.0 (97.4%)	35.0 (45.5%)	**< 0.001**
Postoperative hospital stay, hours			0.126
Median (Q1, Q3)	4.6 (3.6, 15.0)	5.5 (4.0, 21.9)	
Encounter, *N* (%)			0.592
Extended recovery	13.0 (16.7%)	16.0 (20.5%)	
Inpatient	10.0 (12.8%)	13.0 (16.7%)	
Outpatient	55.0 (70.5%)	49.0 (62.8%)	
Pain score at discharge, *N* (%)			0.626
0–1	22.0 (28.9%)	21.0 (28.8%)	
2–3	30.0 (39.5%)	24.0 (32.9%)	
4–6	24.0 (31.6%)	28.0 (38.4%)	
Foley catheter period, days			**< 0.001**
Median (Q1, Q3)	7.0 (7.0, 8.0)	3.0 (3.0, 4.0)	
Surgical margin status, *N* (%)			0.113
Positive	20.0 (25.6%)	12.0 (15.4%)	
Margins involvement, *N* (%)			0.163
Focal (< 3 mm)	10.0 (50.0%)	9.0 (25.0%)	
Non-focal (> 3 mm)	10.0 (50.0%)	3.0 (25.0%)	
Lymph node yield			0.917
Median (Q1, Q3)	5.0 (3.2, 7.0)	4.0 (2.8, 8.5)	
Postoperative complications, *N* (%)	11.0 (14.1%)	10.0 (12.8%)	1.000
Complication type, *N* (%)			0.142
Lymphocele	6.0 (7.7%)	1.0 (1.3%)	
Urinary retention	2.0 (2.6%)	4.0 (5.1%)	
Pelvic hematoma	0.0 (0.0%)	1.0 (1.3%)	
UTI	1.0 (1.3%)	0.0 (0.0%)	
Thromboembolic events	1.0 (1.3%)	0.0 (0.0%)	
Other(ileus, bladder spasm, hematuria)	1.0 (1.3%)	4.0 (5.1%)	
Clavien–Dindo classification, *N* (%)			0.026
1	3.0 (27.3%)	9.0 (81.8%)	
2	3.0 (27.3%)	0.0 (0.0%)	
3a	5.0 (45.5%)	2.0 (18.2%)	
30 Days readmission, *N* (%)	3.0 (3.8%)	4.0 (5.1%)	0.699
Continence at 6 weeks, *N* (%)	35 (47.9%)	48 (71.6%)	**0.004**
Continence at 3 months, *N* (%)	47 (81.0%)	56 (96.6%)	**0.008**
Continence at 6 month, *N* (%)	56 (93.3%)	57 (100.0%)	**0.047**
SHIM score at 3 months, *N* (%)			0.264
5–11	24 (75.0%)	17 (68.0%)	
12–16	6 (18.8%)	3 (12.0%)	
17–25	2 (6.2%)	5 (20.0%)	
SHIM score at 6 months, *N* (%)			0.616
5–11	20 (64.5%)	8 (57.1%)	
12–16	6 (19.4%)	2 (14.3%)	
17–25	5 (16.1%)	4 (28.6%)	
BCR at 6 months	2 (4.0%)	1 (2.5%)	0.862

SHIM Sexual health inventory for men, *BCR* Biochemical recurrence

Bold values are statistically significant

on the final pathology and the median lymph nodes yield was comparable between the 2 groups (4 vs 5, for TVRP and ERP, respectively), the largest lymph nodes yield in our TVRP patients reached 16 lymph nodes. The lymphocele rate was higher in the ERP group. A possible explanation, however, is the lack of lymphatic channels in the extraperitoneal space to absorb the fluid released from the dissected tissues [19]. In response to this, we started to fenestrate the peritoneum at the end of all our SP ERP procedures. After this modification, the rate of postoperative lymphocele decreased to less than 3%.

Decreasing postoperative catheter duration was another key improvement as catheterization is a great source of inconvenience for patients [20]. The fact that the bladder neck incision is just confined to the prostate circumference and the vesicourethral anastomosis is fully completed under direct vision from inside the bladder, reassured us of the fast bladder neck healing and low risk of anastomotic leak [8]. Hence, we have followed a protocol to reduce the catheter duration to 3 days, which has become a successful routine in our transvesical approach. Thus far, only four patients developed acute urinary retention following catheter removal, which prompted a short period of re-catheterization.

Our study is limited by the retrospective design and inherent selection bias. Extended LND is not possible with TVRP; therefore, patients who require extended LND are recommended other approaches in our practice. To limit this selection bias, high-risk ERP cases were excluded after matching. However, despite matching, unmeasured and unknown confounding factors still could not be adjusted. Moreover, all of our cases were done by an expert robotic surgeon (JK), which limits the reproducibility of the results. Furthermore, the sample size is relatively small, and the median follow-up time is short, specifically in the TVRP group. For this reason, we were unable to analyze longer continence, biochemical recurrence, and erection data. Moreover, To limit the data contamination related to selection bias with the SP platform, we only analyzed the ERP cases before introducing the TVRP approach. On the other hand, our analysis is novel, and to our knowledge, this is the first and only study to compare these two surgical techniques in the literature.

Conclusion

TVRP is an alternative approach to ERP. Both single-port approaches provide patients with same-day hospital discharge and minimal pain. However, in our initial series, the TVRP approach may allow for earlier catheter removal and shorter recovery time to urinary continence, without early functional or oncological compromise.

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Author contributions MAZ: project development, data collection, data analysis, manuscript writing/editing. ATB: data collection, manuscript writing/editing. EF: data collection. AK: data collection. JK: project development, manuscript writing/editing.

Declarations

Conflicts of interest Jihad Kaouk, MD. Is a speaker Bureau for Intuitive Surgical Company.

Human participants and/or animals All patients data were collected in an Institutional Review Board approved secured database.

Informed consent All patients were consented on the radical prostatectomy procedure prior to the surgery.

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