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The impact of prostate volume on Retzius-sparing robot-assisted laparoscopic radical prostatectomy with retrograde release of the neurovascular bundle

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Abstract

Objective Robot-assisted radical prostatectomy (RARP) has emerged as a primary treatment modality for localized prostate cancer. In this context, we report a novel surgical technique termed Retzius-sparing robot-assisted laparoscopic radical prostatectomy with retrograde release of the neurovascular bundle (RNRS-RARP). This study aims to assess the perioperative, oncological, and functional outcomes of RNRS-RARP across varying prostate volumes.

Methods A retrospective analysis was conducted on clinical data retrieved from 298 patients who underwent RNRS-RARP from October 2021 to September 2023. Patients were stratified into three groups based on pathological prostate weight: ≤ 30 g, 30–50 g, and ≥ 50 g. Comparative analyses were performed on perioperative and postoperative oncological and functional outcomes among the three groups to discern variations. Separate analyses were performed for patients who received neoadjuvant therapy and those who did not. Additionally, independent predictors of immediate continence following RNRS-RARP were investigated.

Results Patients with larger prostate volumes were significantly older and have higher body mass index and prostate-specific antigen (PSA) (all $p < 0.05$). Larger prostate volumes exhibited prolonged median console time (65 vs. 70 vs. 90 min, $p < 0.01$) and increased median estimated blood loss (95 vs. 90 vs. 100 ml). There were no significant differences in duration of catheterization, length of stay, postoperative complications, positive surgical margin, PSA recurrence after 6 months, 1 month and 3 months continence. Immediate continence worsened with increasing prostate volume (80.0% vs. 77.5% vs. 64.2%, $p = 0.04$). Prostate volume (OR = 0.98; 95% CI: 0.97–0.99; $p = 0.03$), age (OR = 0.90; 95% CI: 0.86–0.95; $p < 0.01$), and clinical T stage (OR = 0.31; 95% CI: 0.13–0.74; $p = 0.01$) were independent risk factors for immediate continence, with an area under the curve of 0.75 in the predictive model.

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Conclusion RNRS-RARP can be safely performed regardless of prostate volume. As prostate volume increases, both console time and estimated blood loss tend to rise. However, the oncological outcomes and complication rates remained similar. Immediate continence was significantly lower with larger prostate volume, which also emerged as an independent predictor.

Clinical trial registration The clinical trial registration number is ChiCTR2200066350 (December1, 2022).

Keywords Prostate cancer, Radical prostatectomy, Prostate volume, Continence

Introduction

Nowadays, prostate cancer has become one of the most common malignant tumors [1]. Robot-assisted radical prostatectomy (RARP) is the standard treatment for localized prostate cancer [2]. Compared to traditional open and laparoscopic surgery, it has obvious advantages in tumor control, potency preservation, and continence [3]. There are several approaches to RARP, such as the traditional anterior approach, posterior approach, extraperitoneal approach and so on [4].

In 2006, El-Hakim et al. [5] first reported on the effect of prostate volume on RARP, demonstrating that console time and estimated blood loss (EBL) were significantly increased in patients with larger prostates. Since then, several studies have examined the influence of prostate volume on RARP outcomes [6, 7, 8, 9, 10]. Most evidence derives from studies utilizing the traditional anterior or extraperitoneal approaches. In contrast, the posterior approach involves a more confined surgical field, increasing technical complexity in cases with larger prostate volumes.

In 2010, Galfano et al. [11] first reported on Retzius-sparing robot-assisted radical prostatectomy. This method provides better continence outcomes compared to traditional operations, but it comes with a long learning curve and operates within a narrow space. We have further improved upon this method: our surgery does not open the Retzius space and enables the retrograde release of the neurovascular bundle (NVB) and ventral prostatic fascia along the prostatic envelope without using Hemo-lok (RNRS-RARP) [12]. This modification has led to improved continence rates [13]. Therefore, this study aimed to retrospectively analyze the impact of prostate volume on RNRS-RARP, specifically focusing on perioperative outcomes, short-term oncological outcomes, and continence. The study sought to determine whether prostate volume influences short-term continence and to identify associated risk factors. Additionally, a clinically relevant nomogram was established to predict short-term continence.

Methods

Collection of clinical information

We conducted a retrospective analysis of 298 patients with prostate cancer who underwent RNRS-RARP at the Second Hospital of Tianjin Medical University from October 2021 to September 2023. The study excluded patients with a history of prior prostate surgery, those lacking preoperative absence of prostate MRI, incomplete clinical data, and loss to follow-up. All procedures were performed by a single surgeon with extensive experience in both anterior and posterior RARP approaches and who had surpassed the learning curve for this technique. The patients were divided into three groups based on the pathological weight of the prostate: group 1 (≤ 30 g, $n = 75$), group 2 (30–50 g, $n = 142$), and group 3 (≥ 50 g, $n = 81$). Clinical data collected included age, body mass index (BMI), prostate-specific antigen (PSA) levels, pathological prostate volume, use of preoperative medication, IPSS score, clinical T stage, and biopsy Gleason score were collected. Similarly, perioperative data including console time, anatomical time for prostate and seminal vesicle dissection, anastomosis time, EBL, Length of stay (LOS), catheterization duration, reduction of hemoglobin, transfusion rate, and early postoperative complications were collected and analyzed. Postoperative outcomes assessed included pathological stage, postoperative Gleason score, positive surgical margin rates (PSM), immediate continence (24-hour continence) (defined as zero pads/day), 1month continence, 3 months continence, and biochemical recurrence (BCR) (two consecutive PSA levels > 0.2 ng/mL). We will remind the patient to come to the clinic or follow up by phone on the day of catheter extraction, 1 month、3 months and 6 months after surgery. The median follow-up duration was 17(11–23) months.

Surgical technique

All patients underwent RNRS-RARP, a modified posterior approach optimized by our center. The bladder was pulled to expose the Dougla space. The peritoneum on the anterior surface of the pouch of Douglas was incised. Vas deferens and seminal vesicles were isolated at the dorsal side without being incised. Blunt dissection was performed at the 6 o'clock position of the prostate to locate and open the Denonvilliers' fascia. Next, the 30°lens was angled upwards, and the Denonvilliers' fascia was separated along the posterior plane of the prostate until reaching the prostate apex. The apex of the prostate was completely freed. The NVB was retrogradely

released adjacent to the prostatic capsule, and the lateral prostatic pedicle was dissected using primarily blunt dissection and precise electrocoagulation, without the use of Hem-o-lok clips. The vas deferens was incised, and the seminal vesicles were isolated. Blunt dissection was continued along the prostate layer to expose the vesicoprostatic junction, after which the bladder neck was sectioned. The surrounding structures were dissected along the anterior periprostatic fascia. During this process, the Retzius space was not opened, and the dorsal venous complex (DVC) was not ligated. The prostatic apex was completely isolated, and the urethra was incised. Regardless of prostate size, the surgeon had chosen according to preference, using the "parachute technique" to reduce the bladder neck, that is, the use of continuous suture method, first the bladder neck and urethra stump loose suture, and then gradually tighten the suture to complete the anastomosis, similar to the expansion and tightening of the parachute. The prostate was removed, and a vesicourethral anastomosis was performed. After completing the anastomosis, posterior reconstruction was performed at 6 o'clock position. The peritoneum was subsequently closed [12]. Postoperatively, all patients had drainage and urinary catheters placed, with the latter typically removed two weeks after surgery.

Table 1 Preoperative patient chrarcteristics of study sujects

Characteristics	≤ 30	30–50	≥ 50	*p*-Value
Number of subjects	75	142	81	
Median Age, years (IQR)	67 (63–71)	68 (64–71)	70(67–75)	< 0.01
Median PSA, ng/mL (IQR)	4.31 (0.07–9.99)	10.29(5.94–18.01)	13.98(7.93–25.60)	< 0.01
BMI, kg/m2 (IQR)	24.22(22.32–26.04)	25.26(23.34–26.57)	25.21(23.67–27.68)	0.04
Median prostate weight, g (IQR)	25.5 (21.9–27.8)	39.5 (34.5–43.8)	61.7(54.9–76.9)	< 0.01
ISUP Grading Groups, n (%)				
1	7(9.3)	24(16.9)	14(17.3)	0.27
2	19(25.3)	36(25.4)	19(23.5)	0.95
3	5(6.7)	26(18.3)	12(14.8)	0.07
4	30(40.0)	39(27.5)	28(34.6)	0.16
5	14(18.7)	17(12.0)	8(9.9)	0.23
Clinical T stage, n (%)				
< T3	63(84.0)	130(91.5)	73(90.1)	0.22
≥T3	12(16.0)	12(8.5)	8(9.8)	
Preoperative IPSS score (IQR)	11(6–17)	14(11–19)	17(11–23)	0.10
Neoadjuvant therapy, n (%)				
Yes	33(44.0)	17(12.0)	6(7.4)	< 0.01
No	42(56.0)	125(88.0)	75(92.6)	

PSA, prostate-specific antigen; BMI, body mass index; ISUP, International Society of Urological Pathology; IPSS, International Prostate Symptom Score

Statistical analysis

The statistical analysis was conducted using Statistical Package for Social Science 25.0 (SPSS 25.0, IBM Corp). Continuous variables were presented as median and interquartile range (IQR), while categorical variables were expressed as quantities and percentages. The Pearson chi-square test was used to compare categorical variables, and the Kruskal-Wallis test was used for nonparametric analysis of continuous variables across the three groups. Univariate and multivariate logistic regression analyses were performed to explore the relationship between independent predictors and immediate continence in the study population. The independent predictors identified in the study were used to develop a nomogram. The construction of the nomogram was carried out using the R software (version 4.2.2, http://www.r-project.org). The receiver operator characteristic (ROC) curves were used to evaluate the discriminative performance of the nomogram, and the area under the curve (AUC) was calculated to evaluate the predictive accuracy. Parameters with a P value < 0.05 were considered statistically significant and all P values were bilateral.

Ethical statement

This study was approved by the Ethical Review Board of the Second Hospital of Tianjin Medical University (Numbers KY2022K046) and carried out in accordance with the principles outlined in the Declaration of Helsinki. Informed consent was obtained from each patient in this study.

Results

Baseline information

A total of 298 patients underwent surgery, and their clinical characteristics are summarized in Table 1. The median (IQR) prostate volumes for the three groups were 25.5 (21.9–27.8), 39.5 (34.5–43.8), and 61.7 (54.9–76.9) g. The median (IQR) ages were 67(63–71), 68(64–71) and 70(67–75). The p values for age, PSA, BMI among the groups were all < 0.05, indicating statistically significant differences. A statistically significant difference was also observed in the proportion of patients who received neoadjuvant therapy ($p < 0.01$). However, no significant differences were observed in clinical T stage or IPSS scores. In the three groups, there were 31(41.3%), 86(60.6%), 45(55.6%) patients with Gleason score ≤ 7, respectively. When stratified by ISUP grade, there was no statistically significant difference among the three groups, but there was a trend of higher proportions of ISUP 4 and 5 in the ≤ 30 group. Of these patients, 56 received neoadjuvant

therapy, while 242 did not. The clinical characteristics are summarized in Supplementary Tables 1 A and 1B.

Perioperative outcome

The perioperative data of the patients were retrospectively collected and are presented in Table 2. The median console times of the three groups were 65 (55–82), 70 (60–90), 90 (65–120) mins, with statistically significant differences ($p < 0.01$). The median anatomical time (43 vs. 50 vs. 60 min, $p < 0.01$) and median anastomosis time (20 vs. 20 vs. 27 min, $p < 0.01$) also increased with increasing prostate volume, and both were statistically significant. In the three groups, 0, 1, and 1 patients received intraoperative blood transfusion. There were no significant differences in the median reduction of hemoglobin (14.0 vs. 17.0 vs. 18.0 g/L, $p = 0.06$) and EBL (95 vs. 90 vs. 100 mL, $p = 0.06$). Similarly, there were no significant differences in the duration of catheterization or the LOS among the three groups. The postoperative complications were recorded, and there was no statistical difference. Among them, one patient developed acute postoperative pulmonary embolism, two patients developed COVID-19 respiratory failure after surgery, and one patient developed renal failure. Subgroup analyses of perioperative outcomes were performed, and the same trend was observed in the non-neoadjuvant group, as detailed in Supplementary Table 2 A. Compared with patients who did not receive neoadjuvant therapy, those treated with neoadjuvant therapy showed increased console time, anatomical time, and anastomosis time, with significant differences among all groups ($p < 0.05$). The changes in hemoglobin and EBL increased with the increase of prostate volume, and the differences were statistically significant. There was no statistical difference in the duration of catheterization, but there was a statistical difference in the LOS of patients, as shown in Supplementary Table 2B.

Pathological outcome

The postoperative pathological and short-term functional data of the patients are shown in Table 3. There were no significant differences in pathological T stage, ISUP grade, overall PSM rate (28.0% vs. 34.5% vs. 23.5%), and BCR rate (4.0% vs. 4.2% vs. 3.7%) among the three groups. The 24-hour immediate continence of the three groups showed a statistically significant difference and decreased with an increase in prostate volume (80.0% vs. 77.5% vs. 64.2%, $p = 0.04$). However, no significant differences were found in continence at 1 month (90.7% vs. 90.1% vs. 83.0%, $p = 0.19$) or 3 months (93.3% vs. 94.3% vs. 87.7%, $p = 0.18$). Subsequently, subgroup analyses were performed. Among patients who did not receive neoadjuvant therapy, there were no statistically significant differences in pathological stage, ISUP grade, BCR, 1 month continence, or 3 months continence. However, there were

Table 2 Perioperative outcomes and postoperative complications of the subjects

Characteristics	≤ 30	30–50	≥ 50	*p*-Value
Number of subjects	75	142	81	
Console time, mins (IQR)	65(55–82)	70(60–90)	90(65–120)	< 0.01
Anatomical time, mins (IQR)	45(35–60)	50(40–60)	60(45–80)	< 0.01
Anastomosis time, mins (IQR)	20(15–25)	20(15–25)	27(20–35)	< 0.01
Estimated blood loss, ml (IQR)	95(80–110)	90(75–110)	100(80–145)	0.06
Blood transfusion, n (%)	0(0)	1(0.7)	1(1.2)	0.64
Length of stay, d (IQR)	8(7–8)	8(7–8)	8(7-8.5)	0.31
Duration of catheterization, d (IQR)	4(4–5)	4(4–5)	4(4–5)	0.39
Reduction of hemoglobin, g/L	14.0(8.0–21.0)	17.0(10.0–23.0)	18.0(12.0–23.0)	0.06
Complications, n (%)	3(4)	4(2.8)	7(8.6)	0.13
Clavien–Dindo grade I	2	2	3	
II	1	1	1	
IV	0	1	3	

Table 3 Oncology outcome and urinary continence of the study subjects

Characteristics	≤ 30	30–50	≥ 50	*p*-Value
Number of subjects	75	142	81	
Pathological ISUP Grading Groups, n (%)				
1	10(13.3)	24(16.9)	14(17.3)	0.75
2	20(26.7)	44(31.0)	26(32.1)	0.73
3	9(12.0)	36(25.4)	16(19.8)	0.07
4	20(26.7)	20(14.1)	16(19.8)	0.08
5	16(21.3)	18(12.7)	9(11.1)	0.14
Pathological T stage, n (%)				
< T3	61(81.3)	108(76.1)	62(76.5)	0.66
≥T3	14(18.7)	34(23.9)	19(23.5)	
PSM, n (%)				
total	21(28.0)	49(34.5)	19(23.5)	0.21
< pT3	14/61(23.0)	28/108(25.9)	6/62(9.7)	0.04
≥pT3	7/14(50.0)	21/34(61.8)	13/19(68.4)	0.56
Urinary continence, n (%)				
24 h	60(80.0)	110(77.5)	52(64.2)	0.04
1 month	68(90.7)	128(90.1)	67(83.0)	0.19
3 months	70(93.3)	134(94.3)	71(87.7)	0.18
BCR at 6 months follow-up, n (%)	3(4.0)	6(4.2)	3(3.7)	0.98

PSM, positive surgical margin; BCR, biochemical recurrence; ISUP, International Society of Urological Pathology

statistical differences in 24-hour immediate continence among the three groups. For patients who received neoadjuvant therapy, there was no statistically significant difference in 24-hour immediate continence. Nevertheless, a trend was observed in which a larger prostate volume was associated with lower 24-hour immediate continence. The detailed findings are presented in Supplementary Tables 3 A and 3B.

We found that immediate continence was different for different prostate volumes. Therefore, logistic regression analysis was performed to identify factors influencing immediate continence rates. Univariate logistic regression analysis indicated that prostate volume (OR = 0.98; 95% CI: 0.97–0.99; $p < 0.01$), age (OR = 0.87; 95% CI: 0.83–0.92; $p < 0.01$), preoperative PSA (OR = 0.98; 95% CI: 0.97–0.99; $p = 0.01$), clinical T stage (OR = 0.25; 95% CI: 0.12–0.53; $p < 0.01$), Gleason score (OR = 0.45; 95% CI: 0.26–0.76; $p < 0.01$), console time (OR = 0.99; 95% CI: 0.98–0.99; $p < 0.01$), anatomical time (OR = 0.98; 95% CI: 0.97–0.99; $p < 0.01$), and anastomosis time (OR = 0.97; 95% CI: 0.95–0.99; $p = 0.01$) were the risk predictors for predicting immediate continence. After assessing the clinical significance of the predictors and excluding collinearity, prostate volume, age, preoperative PSA, clinical T stage, Gleason score, anatomical time, and anastomosis time were included in the multivariate logistic regression analysis. The multivariate logistic regression analysis demonstrated that prostate volume (OR = 0.98; 95% CI: 0.97–0.99; $p = 0.03$), age (OR = 0.90; 95% CI: 0.85–0.95; $p < 0.01$), and clinical T stage (OR = 0.31; 95% CI: 0.13–0.74; $p < 0.01$) were independent predictors of 24-hour immediate continence (Table 4). Subsequently, a prediction model was developed, and these predictors were used to construct a nomogram. The relevant AUC value was calculated to evaluate the predictive performance, resulting in an AUC of 0.751 (Fig. 1).

Table 4 Univariate logistic regression and multivariate logistic regression analysis of immediate continence

Variable	Univariate analysis		Multivariate analysis	
	OR (95% CI)	*p*-Value	OR (95% CI)	*p*-Value
Prostate volume	0.98(0.97–0.99)	< 0.01	0.98(0.97–0.99)	0.03
BMI	1.04(0.96–1.14)	0.33		
Age	0.87(0.83–0.92)	< 0.01	0.90 (0.85–0.95)	< 0.01
Median preoperative PSA	0.98(0.97–0.99)	0.01	1.00(0.98–1.01)	0.60
Clinical T stage				
< T3	0.25(0.12–0.53)	< 0.01	0.31(0.13–0.74)	< 0.01
≥T3				
Gleason score				
≤ 7	0.45(0.26–0.76)	< 0.01	0.60(0.32–1.11)	0.10
> 7				
Console time	0.99(0.98–0.99)	< 0.01		
Anatomical time	0.98(0.97–0.99)	< 0.01	1.00(0.98–1.02)	0.94
Anastomosis time	0.97(0.95–0.99)	0.01	0.99(0.96–1.02)	0.44
Estimated blood loss	0.99(0.99-1.00)	0.18		
Reduction of hemoglobin	0.98(0.96-1.00)	0.11		

BMI, body mass index; PSA, prostate-specific antigen

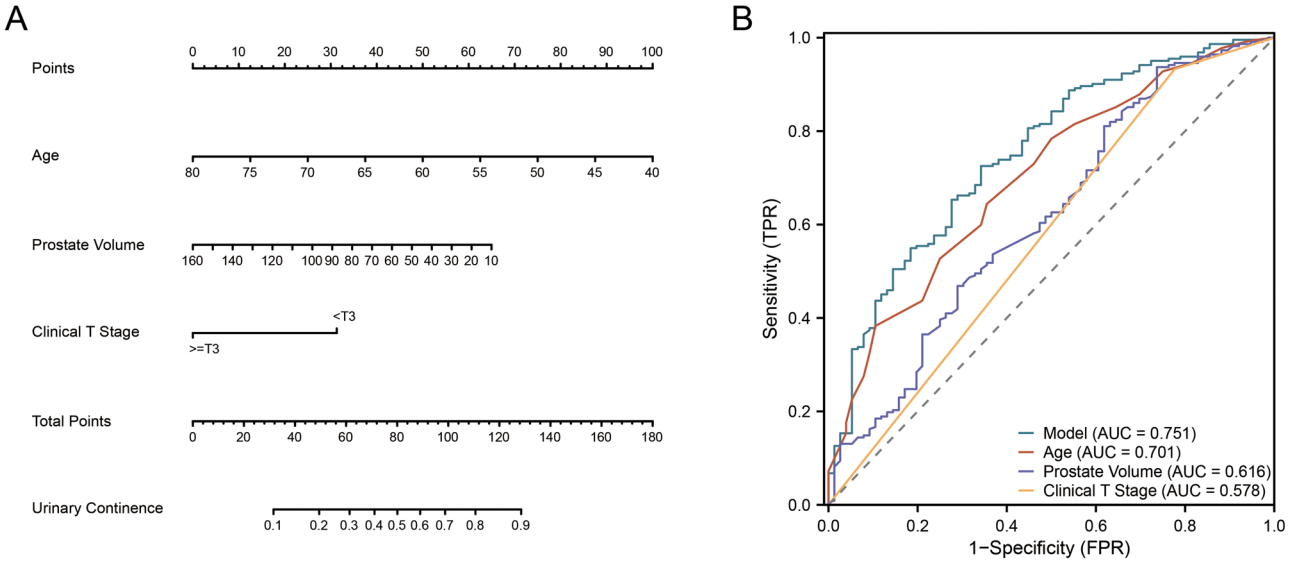

Fig. 1 **A** Nomogram for immediate continence in different prostate volumes. **B** The receiver operating characteristic (ROC) curve of the study for immediate continence. AUC: areas under the ROC curve. Model: A model was constructed by prostate volume, age, and clinical T stage were used to construct a nomogram

Discussion

With advancements in prostate cancer detection methods, the number of diagnosed patients has steadily increased each year [14]. Multiple studies have demonstrated the feasibility of various approaches to RARP for larger prostate volumes [15, 16, 17, 18, 19]. However, the impact of prostate volume on RARP surgery and oncological outcomes remains controversial. In this study, we examined the impact of prostate volume on perioperative outcomes, short-term continence, and related oncological outcomes in patients undergoing RNRS-RNRP. Our findings demonstrated that prostate volumes could influence various outcome measures, including console time, EBL, and 24-hour immediate continence. Furthermore, we identified prostate volume as an independent risk factor for 24-hour immediate continence.

In this retrospective study, postoperative pathology was analyzed in relation to prostate volume, revealing that patients with larger prostates tended to be older and have higher PSA levels. This finding aligns with the trends reported in most studies [6, 20]. The association between benign prostatic hyperplasia and elevated PSA levels may explain this trend [21]. A higher number of patients with ISUP4 and ISUP5 were observed in the ≤ 30 group, likely due to a larger proportion of patients in this group receiving neoadjuvant therapy, leading to a reduction in prostate volume. Further analysis revealed that among patients who did not receive neoadjuvant therapy, larger prostate volumes were associated with older age and higher PSA levels.

In this study, the console times were 65, 70, and 90 min ($p < 0.01$), and the console time increased gradually with prostate volume. Similarly, anatomical time and anastomosis time also increased progressively and showed statistically significant differences. In our previous study, we compared this procedure with the traditional posterior approach and observed a significant reduction in console time. Studies have confirmed that prostate volume is an independent risk factor affecting the perioperative outcomes, with larger prostate volumes associated with prolonged console times [22, 23]. This study documented perioperative data across varying prostate volumes and observed corresponding variations in console times. In a study by Santok et al. [24], the console times for groups with prostate volumes of < 40, 40–60, and > 60 g undergoing posterior approach surgery were reported as 93, 92, and 100 min. Bocciardi et al. [9] reported that as prostate volume increased, the corresponding console times for the three groups were 90, 100, and 100 min. Compared to these studies, our cohort demonstrated reduced surgical times. We observed that increased prostate volume was associated with higher EBL, although this difference was not statistically significant. Furthermore, there were no statistically significant variances in reduction of hemoglobin, transfusion rates, LOS or duration of catheterization. Additionally, it was found that increased prostate volume did not lead to a rise in perioperative complications ($p = 0.13$). Kim et al. [7] reported that differences in EBL by prostate volume (< 25 vs. 25–50 vs. 51–75 vs. > 75 g, 347 ± 250 vs. 386 ± 262 vs. 456 ± 303 vs. 646 ± 423 mL, $p < 0.01$), but no significant differences in transfusion rates (1.3% vs. 0.2% vs. 0.7% vs. 2.6%, $p = 0.67$). Santok et al. [24] reported that the EBL (< 40 vs. 40–60 vs. > 40 g, 250 (150–400) vs. 200 (150–400) vs. 475 (312–575) mL, $p < 0.01$), and blood transfusion (0.4% vs. 4.2% vs. 12.5%, $p < 0.01$) were different with different prostate volumes. Our study demonstrates that surgeons dealing with large prostates may increase the console time of operation without excessive perioperative complications.

There was no significant difference in postoperative T stage among the groups, but a significant difference was observed in postoperative pathological Gleason score. The proportion of patients with a Gleason score of ≤ 7 in the small prostate group was 52%, lower than the 69.1% observed in the large prostate group. A similar trend was observed when patients were grouped by ISUP grade. In the < 30 g group, the proportion of ISUP4 and 5 was higher. This difference may be attributed to the fact that some patients in the small prostate group had received neoadjuvant therapy prior to surgery. In the subgroup analysis, no statistically significant differences were observed in T stage or ISUP grade among patients with different prostate volumes who had not received neoadjuvant therapy. The overall PSM rate of all patients was 29.8%, with rates of 28.0%, 34.5%, and 23.5% in the three groups, respectively ($p = 0.21$). The > 50 g group had a lower PSM rate compared to the < 30 group, consistent with findings from other studies [20, 24]. However, the PSM rate of our large volume group was slightly higher than that reported by other studies, which was 14.3% reported by Wang et al. and 19% reported by Stolzenburg et al. [25, 26]. In this study, the posterior approach optimized by our center was used for surgery, which was similar to the PSM rate of conventional posterior approaches reported in the literature (24%). These rates are higher than those reported for traditional RARP (15.2%) [23]. The BCR reported in this study were 4.0%, 4.2%, and 3.7%, respectively ($p = 0.98$), which proved that prostate volume was not related to BCR, probably due to the short follow-up period and small sample size. It has been reported that increased prostate volume may reduce BCR in patients [27], and Jaber et al. [28] recently reported that prostate volume may influence the BCR.

After Galfano et al. [11] reported the posterior approach with Retzius preservation, numerous studies have been conducted on its efficacy and outcomes. The posterior approach maximally preserves the Retzius

space、nerves around the prostate and bladder neck. In 2013, he reported the recovery of continence in 200 cases using the posterior approach. The continence rate of patients within 1 week was 92%, 90% (using one pad ≤ 1 piece/24 h), and the proportion decreased to 76% when defined as 0 piece/24h [29]. Furthermore, recent studies have demonstrated that intraoperative resection of the prostatic margins adjacent to the neurovascular structures during radical prostatectomy, combined with real-time frozen section analysis, can better preserve the peri-prostatic nerves [30]. Although this approach has not shown significant improvements in long-term oncological and urinary continence outcomes, it offers a higher proportion of patients the opportunity to achieve improved postoperative functional results.Several studies have reported that the posterior approach results in better continence outcomes compared to the anterior approach [31, 32, 33, 34].

In 2020, Guo et al. [31] reported a study including all high-risk patients. Out of 55 cases, the continence rate within 1 week was 69.1% for the posterior approach, while it was 30.9% for the anterior approach (defined as not using any pad/24 h for 1 week). In a study by Egan et al. [35], 70 patients who underwent posterior approach surgery had better continence at 12 months (97.6% vs. 81.4%, $p < 0.05$) compared to patients who underwent standard anterior approach surgery. It was also shown to restore better urinary continence during long-term follow-up. When defined as using 0–1 pad per day, the median time to return to continence was 44 days and 131 days ($p < 0.01$). Yee et al. [36] reported on 48 patients who underwent posterior and anterior approach surgery, most of them had pT2 disease (87.5% vs. 79.2%). More patients in the posterior approach group achieved immediate continence (33.3% vs. 0%) and 3-month continence (66.7% vs. 12.5%). During the follow-up period, there were also more patients with the posterior approach when the use of 0 pads was defined as continence. Galfano et al. [9] discovered a variation in immediate continence rates among patients with different prostate volumes who underwent surgery using the posterior approach. In the < 40, 40–60, > 60 g groups, immediate continence rates (defined as the use of ≤ 1 pad /24 h for 1 week) were 88.2%, 89.5%, 81.3%, and there were statistical differences ($p < 0.05$). In a study conducted by Philipp et al. [37], when urine continence was defined as using no more than 1 piece of pad within 24 h, the 1-week continence in the < 30, 30–50, 50–70, ≥ 70 group were 64.4%, 64.2%, 59.4%, 55.6%, which also had a statistical difference ($p = 0.012$). Our study observed a similar trend and achieved favorable continence outcomes. Immediate continence in our study was defined as not using any pads for a full 24-hour period, with rates of 80%, 77.5%, and 64.2% in the three groups.

Through univariate and multivariate logistic regression analyses, our study found that prostate volume was a significant protective factor for immediate continence following RNRS-RNRP (OR < 1). Additionally, age and preoperative T stage were also independent risk factors for immediate continence. We combined these factors to establish a clinical prediction model and constructed a corresponding nomogram to predict immediate continence. The AUC value of the nomogram was 0.75, indicating its potential clinical significance.

This study has certain limitations that should be acknowledged. Firstly, the follow-up period was relatively short, therefore, only short-term outcomes were evaluated. Secondly, our assessment of continence relied on outpatient follow-up visits and telephone interviews, which may introduce a degree of inaccuracy. Finally, this was a single-center study with a relatively small sample size. The study included patients who did not receive treatment before surgery and those who received treatment before surgery. To address these limitations and ensure the reliability and generalizability of the results, a multi-center, large-sample, prospective study is necessary to validate our results.

Conclusion

In conclusion, our study suggests that RNRS-RARP can be performed irrespective of prostate volume, and all achieved good immediate continence. However, larger prostate volumes were associated with longer operative times and poorer immediate continence outcomes. Notably, the impact of prostate volume on continence tends to diminish over time. Prostate volume was identified as an independent risk factor for immediate urinary continence following RNRS-RARP.

Abbreviations

RARP	Robot-assisted radical prostatectomy
RNRS-RARP	Retzius-sparing robot-assisted laparoscopic radical prostatectomy with retrograde release of the neurovascular bundle
EBL	Estimated blood loss
NVB	Neurovascular bundle
BMI	Body mass index
PSA	Prostate-specific antigen
LOS	Length of stay
PSM	Positive surgical margin
BCR	Biochemical recurrence
AUC	Areas under the curve
ROC	Receiver operator characteristic

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

Supplementary Material 5

Supplementary Material 6

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Author contributions
LY and LZH designed the study and were major contributors to the writing of the manuscript. WZ, SY, YZ, HH, WZY, FZN, WSM were the main participants in the surgery and helped collect the data. NYJ and WY supervised and reviewed the manuscript.All authors reviewed the manuscript.

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Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical approval
The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was approved by the Ethical Review Board of the Second Hospital of Tianjin Medical University (Numbers KY2022K046) and carried out in accordance with the principles outlined in the Declaration of Helsinki. Informed consent was obtained from each patient in this study.

Patient consent statement
Informed consent was obtained from all subjects involved in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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