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Robotic prostatectomy for large-volume prostates in prostate cancer: a retrospective analysis of 50 cases (>100 ml)

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Abstract

Objective To assess the clinical application and efficacy of robotic radical prostatectomy in 50 cases of large-volume (> 100 ml) prostate cancer.

Method A retrospective analysis was conducted on 50 patients with large-volume (> 100 ml) prostate cancer who underwent robotic radical prostatectomy from June 2020 to August 2023. Patient ages ranged from 55 to 77 years (mean: 66.5 ± 10.5 years). Total PSA levels ranged from 7.9 to 98.5 ng/ml (mean: 18.7 ± 9.3 ng/ml), and the f/t PSA ratio ranged from 0.12 to 0.94 (mean: 0.35 ± 0.21). Gleason scores were: 15 scored 7, 24 scored 8, 10 scored 9, and 1 scored 10. Preoperative evaluations included lab tests, pelvic MRI, and whole-body bone scans. Patients without surgical contraindications underwent robotic radical prostatectomy.

Results All surgeries were completed without conversion to open surgery or major vascular injuries. Operative time ranged from 80 to 150 min (mean: 105 min). Blood loss ranged from 30 to 450 ml (mean: 110 ml), with no transfusions required. Postoperative hospital stays ranged from 2 to 8 days (mean: 4.5 days). Catheter removal occurred between 3 and 7 days postoperatively (mean: 4 days). Time to first flatus ranged from 1 to 3 days (mean: 1.5 days). Two cases had postoperative lymphatic leakage. Pathology revealed positive surgical margins in 3 cases, with stage distribution of 22 in T2a, 15 in T2b, 7 in T3a, and 6 in T3b; 2 cases had positive lymph nodes. Follow-up ranged from 2 to 26 months (median: 12.5 months). The one-year biochemical recurrence rate was 7.9% (3/38), and the one-year urinary continence satisfaction rate was 92.1% (35/38).

Conclusion Robotic radical prostatectomy for large-volume prostate cancer, despite its surgical challenges, is a safe and feasible approach. With sufficient surgical experience and case volume, satisfactory outcomes can be achieved.

Keywords Prostate cancer, Robotic surgery, Large-volume prostate, Radical prostatectomy, Complications

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Introduction

In the world, prostate cancer represents one of the most common malignancies within the urological reproductive system, exhibiting an increasing incidence trend [1]. Alongside the widespread adoption of robotic surgery in urology in recent years, the number of robotic-assisted radical prostatectomies has also risen [2, 3].

Whether through open surgery or minimally invasive techniques, managing large-volume prostates remains a significant challenge and difficulty during radical procedures. Addressing how to reduce the complexity of robotic-assisted radical prostatectomy for treating large-volume prostate cancer has been a continuous area of contemplation and exploration for the surgical team.

However, the definition of large prostate volume remains unclear. Referring to previous studies and based on our clinical experience, patients with prostate volumes > 100 mL are associated with higher surgical difficulty and increased postoperative complications. Therefore, we selected patients with prostate volumes > 100 mL as the target population for inclusion in this study [4]. From June 2020 to August 2023, the team has successfully performed 50 such procedures, achieving satisfactory outcomes.

Materials and methods

Clinical data

This retrospective statistical analysis included 50 patients who underwent robotic radical prostatectomy from June 2020 to August 2023. In accordance with the Declaration of Helsinki, the inclusion criteria are as follows: Patients who are 18 years of age or older, diagnosed with prostate cancer, and whose prostate volume is greater than 100 ml as evaluated by transrectal ultrasound, and are willing to sign the informed consent form. All enrolled patients provided written informed consent and the study was approved by the Ethics Committee of the Second Affiliated Hospital of Naval Medical University, Shanghai (Ethical approval number:2020SL073). All patients had prostate volumes exceeding 100 ml, with ages ranging from 55 to 77 years (mean age 66.5 ± 10.5 years). Total PSA levels ranged from 7.9 to 98.5 ng/ml, with a mean of 18.7 ± 9.3 ng/ml, and f/t PSA ranged from 0.12 to 0.94, with a mean of 0.35 ± 0.21. All patients underwent transperineal ultrasound-guided prostate biopsy prior to surgery, which confirmed the diagnosis of prostate cancer. The Gleason scores were distributed as follows: 15 patients scored 7 (6 scored 4 + 3 and 9 scored 3 + 4), 24scored 8, 10 scored 9, and 1 scored 10 (Table 1). Five patients had a history of secondary prostate biopsy, eight had undergone transurethral resection of the prostate, and three had received neoadjuvant "hormonal therapy" before surgery. Preoperative evaluations included routine urinalysis, electrocardiogram, chest radiography, abdominal ultrasonography, and cardiopulmonary function tests to exclude any surgical contraindications. Additionally, all patients underwent cystoscopy to determine the position of the bladder neck and ureteric orifices, transrectal ultrasound to measure prostate dimensions (left-right, anterior-posterior, superior-inferior), and pelvic MRI to assess tumor lesions, local invasion, and lymph node metastasis. Whole-body bone ECT scans were performed to exclude distant metastasis. Furthermore, for patients with a PSA > 20 ng/ml, PET-CT was conducted to rule out distant metastases.

Table 1 Patient characteristics

Characteristics	Number	Mean (SD) or %
Number of cases	50	
Age, years		66.5(10.5)
PSA (ng/mL)		18.7(9.3)
Prostate volume, mL		>=100
Gleason score		
	7	15
	8	24
	9	10
	10	1

Inclusion criteria Confirmed biopsy pathology, and transrectal ultrasound estimated prostate volume greater than 100 ml (calculated as left-right diameter × anterior-posterior diameter × superior-inferior diameter × 0.52) [5].

Exclusion criteria Poor cardiopulmonary function, unable to withstand surgery, or other contraindications to surgery; history of preoperative radiation therapy; history of major abdominal surgery prior to the prostatectomy; refusal to undergo robotic surgery; evidence of distant metastasis.

Surgical technique

The surgical approach was standardized across all cases. Patients were intubated and placed under general anesthesia. The patient was positioned in a Trendelenburg position at a 35-degree incline with knees slightly bent and hips abducted, secured with straps. Arms were tucked at the sides. A 1.5 cm vertical skin incision was made 1.0 cm above the umbilicus to establish pneumoperitoneum and insert a 12 mm Trocar for the camera port. Mechanical arm ports were placed on both sides below the umbilical plane at the mid-clavicular line (8 mm, with the right side as arm 1 and left side as arm 2) and a third arm was placed along the anterior axillary line at the left subcostal level. A 12 mm assistant port was established above the midpoint between the camera and arm 1 by 1 cm, and another 12 mm assistant port was placed 4 cm below the umbilicus along the right anterior

axillary line. The robotic system was positioned between the patient's legs, close enough to facilitate easy movement of the arms without hindrance. Each robotic arm was then connected to its corresponding instrument.

Surgical procedure

Mobilizing the prostate and opening the pelvic fascia

The peritoneum at the top of the pelvis is incised to expose and mobilize the space behind the pubis, clearing the fatty tissue from the surface of the prostate. The pelvic fascia is then revealed and opened. The puboprostatic ligaments are severed as the dissection proceeds laterally to the apex of the prostate, exposing the Dorsal Venous Complex (DVC). The DVC is ligated with 2 – 0 absorbable sutures. During ligation, the urinary catheter is mobilized to prevent overly deep suturing that could damage the urethra. (Fig. 1A)

Divtion biding the bladder neck

The juncetween the prostate and the bladder neck can be approximated by manipulating the catheter. It is recommended to cut close to the bladder side of the neck, without the need to intentionally preserve a smaller bladder neck ("cherry-like aperture"). After opening the bladder, the positions of both ureteric orifices are identified, and if necessary, double-J stents are preoperatively placed. The bladder wall is incised starting from a line drawn distally from the ureteric orifices. (Fig. 1B)

Separating the prostate from the seminal vesicles

Due to the large prostate volume, visibility and space for maneuvering are limited, making simultaneous dissection from both sides of the posterior prostate challenging. Thus, dissection may commence from one seminal vesicle, moving from lateral to medial, and once completely mobilized, the contralateral side is freed in sequence, cutting the vas deferens accordingly. (Fig. 1C)

Dissecting denonvilliers' fascia and managing the prostate pedicles

Arm 2 and an assistant's grasper hold the seminal vesicles and vas deferens. Denonvilliers' Fascia is horizontally opened at the base of the vas deferens, and dissection alternates from left to right, bluntly separating the fascia towards the apex. Hem-o-lok clips are used to sever the prostate pedicles until the surgical space becomes too restricted to accurately identify anatomical structures. (Fig. 1D)

Separating the apical region of the prostate

The visual field is adjusted to the anterior of the prostate, and the assistant and auxiliary arm retract the prostate laterally and posteriorly to maintain tension on the apical portion. The DVC is transected, and as much urethra as possible is dissected away, freeing the prostate anteriorly to ensure complete removal. (Fig. 1E)

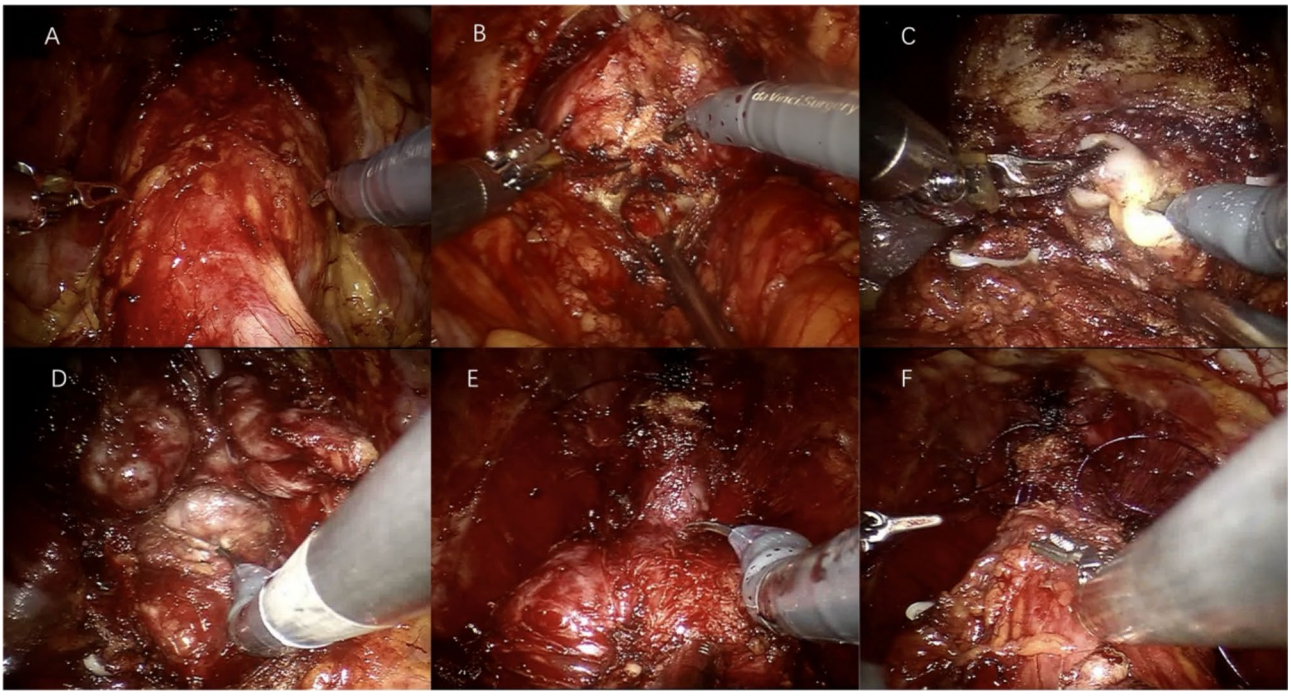

Fig. 1 Surgical procedure

Anastomosing the bladder neck to the urethra

3 – 0 absorbable sutures are used to stitch the posterior wall of the bladder to the posterior wall of the urethra, reducing tension between the urethra and bladder neck. If the bladder neck is wide, it may first be narrowed using continuous suturing with 3 – 0 absorbable thread. The anastomosis typically employs a continuous suture technique using Quill 0 suture with double-needle barbs, sewing from the 6 and 7 o'clock positions to the 11 and 1 o'clock positions. After completing the suturing, the anterior bladder wall tissues are suspended from the posterior pubic surface to aid in postoperative urinary control recovery. (Fig. 1F)

Follow-up methods

Follow-up duration ranged from 2 to 26 months, with a median follow-up time of 12.5 months. The follow-up assessments primarily included PSA levels and urinary control status. PSA Monitoring: Patients were tested monthly for PSA during the first six months post-surgery, then once every three months up to two years postoperatively, and subsequently every six months. Based on PSA results, the need for additional whole-body bone ECT and pelvic MRI assessments was determined by the physician. Urinary Control Standards: Patients were considered to have satisfactory urinary control if they did not experience incontinence while standing or walking and used no more than one urinary pad per day. Biochemical Recurrence: Biochemical recurrence was defined as having a PSA level of ≥ 0.2 ng/ml on two consecutive tests.

Statistical methods

The statistical analysis was performed using the SPSS software (version 22.0, IBM Corp., Armonk, NY, USA). Descriptive statistics were utilized to summarize patient characteristics, surgical details, and postoperative outcomes. Continuous variables, such as age, prostate volume, surgical time, blood loss, and length of hospital stay, were presented as means ± standard deviations. Categorical data, including Gleason scores, pathological stages, and postoperative complications like lymphatic leakage and positive surgical margins, were expressed as frequencies and percentages.

Results

All procedures in this group were successfully completed without the need for conversion to open surgery, and there were no occurrences of rectal or major vascular injuries. The duration of surgery ranged from 80 to 150 min, with an average of 105 ± 20.4 min. Blood loss during the procedures ranged from 30 to 450 ml, with an average of 110 ± 42.6 ml, and none of the patients required blood transfusions. The postoperative hospital stay ranged from 2 to 8 days, with an average of 4.5 ± 1.2 days. The pelvic drain was removed between 3 and 7 days postoperatively, averaging 4.0 ± 1.5 days. The time to first flatus post-surgery was between 1 and 3 days, with an average of 1.5 ± 0.5 days. There were two instances of postoperative lymphatic leakage(Table 2).

Table 2 Intraoperative outcomes

	Value(SD; range)
Operative time, min	105(20.4;80–150)
Blood loss, ml	110(42.6;30–450)
blood transfusion, ml	0
The postoperative hospital stay, day	4.5(1.5;2–8)
The time of pelvic drain, day	4.0(1.5;3–7)
The time of first post-surgery, day	1.5(0.5;1–3)
postoperative lymphatic leakage	2

Table 3 Postoperative outcomes

	Numbers
Pathologic outcomes	
Stage	
T2a	22
T2b	15
T3a	7
T3b	6
PSM	3
positive lymph nodes	2

Pathological Outcomes: Positive surgical margins were found in three cases. The distribution of prostate cancer staging was as follows: 22 cases were classified as T2a, 15 as T2b, 7 as T3a, and 6 as T3b. Two cases had positive lymph nodes(Table 3).

Follow-up Outcomes: The biochemical recurrence rate at one year postoperatively was 7.9% (3 out of 38 patients). The one-year postoperative urinary continence satisfaction rate was 92.1% (35 out of 38 patients). Among them, 12 patients were lost to follow-up due to reasons such as death, comorbidities and multiple illnesses, relocation from the area, or unwillingness to return to the hospital.

Discussion

While there is no consensus on the threshold for defining a large-volume prostate, literature reports values such as 70 g, 80 g, 90 g, and 100ml [6–8]. It is clear, however, that the larger the prostate, the more challenging the surgical procedure becomes, whether open or minimally invasive. This is primarily due to several factors: a large prostate occupies substantial surgical space, complicating the exposure of critical anatomical landmarks such as the prostate apex, seminal vesicles, and lateral pedicles. There is also an increased risk of intraoperative bleeding and prolonged surgical duration. A large prostate often extends into the bladder, which can result in damage to the bilateral ureteric orifices during separation of the

bladder neck from the prostate, and the rectum may be at risk during dissection along the posterior lip of the bladder [9–12].

Since initiating robotic radical prostatectomy in 2015, the surgeon has completed over 500 cases, with approximately 10% of patients having a prostate volume exceeding 100 ml. Statistics show that these patients had an average operative time of about 105 min and an average blood loss of approximately 110 ml. There were no complications such as rectal or major vascular injuries, and the positive surgical margin rate was 6.0% (3/50) [8]. The one-year postoperative urinary continence satisfaction rate was 92.1%, comparable to those with normal-sized prostates and superior to reports from other centers within the same institution. Continuous accumulation of surgical experience and optimization of the operative procedures have contributed to enhanced surgical outcomes. Key insights include:

Management of the Bladder Neck: Handling large-volume prostates often involves dealing with an intravesical protrusion of the median lobe of the prostate, leading to a significant defect post-resection. It is crucial to manipulate the catheter repeatedly before transecting the bladder neck to accurately determine the junction and minimize bladder damage. Achieving a "cherry-like aperture" is often not feasible; reconstruction of the bladder neck is required prior to anastomosis with the urethra. Additionally, using 3 – 0 absorbable sutures for reinforcing the posterior wall and suspending the anterior wall can reduce anastomotic tension and improve postoperative urinary control. Precise identification of the ureteric orifices during bladder neck handling is critical. The robotic system's flexible arms can facilitate the intraoperative placement of double J stents, effectively preventing damage to the ureteric orifices.

Handling of the Seminal Vesicles and Lateral Pedicles: Due to the large prostate volume, the limited operative space restricts the flexibility to manipulate the prostate. Thus, lifting and freeing the median lobe of the prostate via a posterior midline approach to access Denonvilliers' fascia and the seminal vesicles can be challenging. An alternative lateral approach can be adopted for dividing the posterior lip of the bladder, initially exposing one side of the seminal vesicles, increasing the mobility of that side of the prostate, and then leveraging this mobility to free the opposite seminal vesicle. Throughout this process, close adherence to the prostate side is maintained to avoid damaging the rectum. The handling of the lateral pedicles of the prostate utilizes a stepwise alternating left-right approach, advancing towards the prostate apex with the sequence of "free-Hem-o-lok clip-close-free."

Management of the Dorsal Venous Complex (DVC): For a prostate of normal size, ligation of the DVC typically begins after opening the pelvic fascia and cutting the puboprostatic ligaments. However, exposing the apical part of a large prostate can be particularly difficult, and imprecise separation may lead to inaccurate ligation of the DVC, causing significant bleeding. To address this, if the anatomical layers cannot be precisely identified during the division of the pelvic fascia and the puboprostatic ligaments, it is advisable to initially manage the bladder neck, posterior seminal vesicles, and lateral pedicles, progressing from posterior to anterior. This approach ensures a more accurate exposure of the prostate apex, allowing for subsequent DVC ligation and more effective hemostasis, thus reducing the risk of significant intraoperative bleeding.

In summary, compared to surgeries on prostates of normal size, radical prostatectomy on large-volume prostates presents greater challenges; however, the use of robotic assistance for radical prostatectomy in treating large-volume prostate cancer is safe, feasible, and capable of achieving satisfactory surgical outcomes once a certain number of cases and experience have been accumulated.

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Author contributions
Y.W. and Y.C. worte the main manuscript text and L.S. counted and analyzed the data. J.R. , W.C. , L.Y. , D.X. and S.R. participated in and completed the surgery. S.R. directed the writing of the article. All authors reviewed the manuscript.

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Data availability
The dataset generated and analysed during the current study are not publicly available as the conditions of the ethics approval do not permit public archiving of the data but are available from the corresponding author on reasonable request.

Declarations

Competing interests
The authors declare no competing interests.

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