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ORIGINAL ARTICLE

Outcomes over 20 years performing robot-assisted laparoscopic prostatectomy: a single-surgeon experience

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Abstract

Objective To evaluate a single surgeon's 20-year experience with robotic radical prostatectomy.

Methods Patients who had undergone robot-assisted laparoscopic prostatectomy by a single surgeon were identified via an IRB approved prospectively maintained prostate cancer database. Patients were divided into 5-year cohorts (cohort A 2001–2005; cohort B 2006–2010; cohort C 2011–2015; cohort D 2016–2021) for analysis. Oncologic and quality of life outcomes were recorded at the time of follow-up visits. Continence was defined as 0–1 pad with occasional dribbling. Potency was defined as intercourse or an erection sufficient for intercourse within the last 4 weeks.

Results Three thousand one hundred fifty-two patients met criteria for inclusion. Clavien ≥ 3 complication rates decreased from 5.9% to 3.2%, $p = 0.021$. There was considerable Gleason grade group (GG) and stage migration to more advanced disease between cohort A (6.4% GG4 or GG5, 16.2% pT3 or pT4, 1.2% N1) and cohort D (17% GG4 or GG5, 45.5% pT3 or pT4, 14.4% N1; $p < 0.001$). Consistent with this, an increasing proportion of patients required salvage treatments over time (14.6% of cohort A vs 22.5% of cohort D, p < 0.001). 1-year continence rates improved from 74.8% to greater than 92.4%, $p < 0.001$. While baseline potency and use of intraoperative nerve spare decreased, for patients potent at baseline, there were no significant differences for potency at one year ($p = 0.065$).

Conclusions In this 20-year review of our experience with robotic prostatectomy, complication rates and continence outcomes improved over time, and there was a migration to more advanced disease at the time of surgery.

Keywords Prostatectomy · Robotics · Prostate cancer · Review · Outcomes

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Introduction

Prostate cancer (PCa) is the most commonly diagnosed non-cutaneous malignancy in American men and is the second leading cause of cancer-related death. The American Cancer Society estimates for 2022 indicate that approximately 268,490 new cases of prostate cancer will be diagnosed in the United States, and that 34,500 deaths will be directly attributable to the disease [1]. For those men who are diagnosed with clinically localized prostate cancer, potentially curative treatment options include radical prostatectomy (RP) or radiation therapy (RT).

FDA approval of the daVinci® surgical system was granted in 2000, and subsequently Binder and Kramer published the first report of robot-assisted laparoscopic prostatectomy (RALP) in 2001 [2]. Prior to this, radical prostatectomies were performed primarily using an open approach, with widespread adoption of a laparoscopic approach limited by the technical demands of the procedure. Since 2001, use of RALP has increased rapidly; it is now the most common surgical approach for prostatectomy in the United States [3]. Patients undergoing RALP experience shorter hospital stays, fewer transfusions, fewer complications, and fewer readmissions relative to those undergoing open surgery. [4–7]

Sivaraman et al. [8] studied learning curve trends over a 15-year period at a single institution in an analysis representing 5547 patients with localized prostate cancer treated with minimally invasive radical prostatectomy (3846 laparoscopic and 1701 RALP). They noted a correlation between surgical experience and oncological outcomes in both approaches. Specifically, rates of positive surgical margin (PSM) and biochemical recurrence (BCR) improved with time over the course of a surgeon's learning curve.

To our knowledge, no previous group has presented data representing 20 years of experience performing robot-assisted laparoscopic prostatectomy in a cohort of men in the United States. We have collected data on a single surgeon's experience, which included initiation of robotics programs at two tertiary medical centers starting in 2001. The past 20 years has seen dramatic changes in the landscape of prostate cancer treatment. Here, we describe our experience performing RALP over this time period.

Methods

After IRB approval was obtained from both institutions (IRB E-HHC-2021–0277), we retrospectively queried our IRB approved prospectively maintained prostate cancer database to identify patients who underwent a RALP performed by a single surgeon from October 1, 2001–September 30, 2021; of note, the initial 74 cases were performed as a co-surgeon. The 3-arm S, 4-arm S, Si, and Xi daVinci surgical systems were utilized; the generation of robot for each procedure was not recorded. Data collection included demographics, clinical measures (e.g., pathologic Gleason Grade Group (GG), pathologic T stage, follow-up time, diagnostic PSA), and post-surgical outcomes. Post-surgical and long-term outcomes included surgical time, degree of nerve spare (defined as > 50% of nerve spared on that side), length of stay, complications, positive surgical margins, follow-up PSAs, frequency and timing of biochemical recurrence (BCR; defined as PSA > 0.2 ng/ml or initiation of salvage therapy in the setting of a detectable PSA < 0.2 ng/ml), and the use of radiation therapy or other salvage treatment.

Quality of life data included preoperative and postoperative urinary and sexual function and bother scores from the Expanded Prostate Cancer Index Composite (EPIC) and/or UCLA Prostate Cancer Index [9, 10]. Continence was defined as use of 0 pads or 1 pad with occasional dribbling [11]. Potency was defined as having had intercourse or an erection sufficient for intercourse within the last 4 weeks [12], with or without the use of PDE5 inhibitors. RALP was performed using Intuitive Surgical's daVinci platform, with a modified Mountsouris approach that has previously been described [13].

The standard follow-up regimen for patients included an office visit with PSA, digital rectal exam, and EPIC questionnaire every 3 months for first year, every 6 months for second year, and annually thereafter. Patients not following up at our institution were mailed EPIC forms and surveys yearly. As ultrasensitive PSAs became increasing available in 2008, they are now used exclusively for follow-up.

For analysis, patients were divided into four cohorts, each spanning five years (cohort A 2001–2005; cohort B 2006–2010; cohort C 2011–2015; cohort D 2016–2021, with each five year interval beginning October 1 of the first year and ending September 30 of the last year) and we evaluated group differences in perioperative, quality of life, and oncologic outcomes over time. Between-group differences were evaluated with a chi-square test for categorical variables, and a Kruskal–Wallis test for continuous variables. Kaplan–Meier estimates were used for biochemical recurrence comparisons. SPSS version 26 was used for all analyses. Statistical significance was set at $p < 0.05$.

Results

Patient demographics

From 2001 to 2021, a total of 3152 patients underwent robotic prostatectomy. The distributions of patients across cohorts A, B, C, and D were 437, 1065, 920, and 730, respectively. Demographic, perioperative, and postoperative outcomes are summarized in Table 1. Median age increased steadily from 59 in cohort A to 63 in cohort D. Follow-up was similar between the first 3 cohorts with shorter follow-up for the most recent cohort $p > 0.001$ (medians 61, 60, 60, and 23 months for cohort A, B, C, and D, respectively). Median BMI also increased over time ($p < 0.001$; Table 1). The proportion of patients having surgery after a period of active surveillance increased over time from 0% to 7.5% ($p < 0.001$).

Perioperative outcomes

Median (and interquartile range, IQR) operative time (OT; defined as skin to skin) initially declined from cohort A (199 min, IQR 169–242) to cohort B (167 min, IQR 144–193), then subsequently increased in cohort C (185 min, IQR 155–216) and cohort D (213 min, IQR 170–242; $p < 0.001$). The utilization of lymph node dissection increased over time from 39.1% in cohort A to 92.1% in cohort D. Median length of stay decreased from 2 days in cohort A to 1 day in subsequent cohorts ($p < 0.001$). 90-day Clavien ≥ 3 complication rates were the highest in the initial cohort and subsequently declined, with events in 5.9% of cohort A patients, down to 2.8%, 3.3%, and 3.2% in cohorts B, C, and D, respectively. When reviewing the specific complications of 90-day urine leaks and bladder neck contractures (BNC) requiring dilation procedures (at any time), a similar pattern was seen. In cohorts A, B, C, and D urine leaks occurred in 2.3%, 0.1%, 0.4%, and 0.1% of

Table 1 Baseline and perioperative statistics

	Cohort A	Cohort B	Cohort C	Cohort D	*P*
Median age at surgery (IQR)	59 (54–63)	60 (55–65)	62 (57–66)	63 (59–68)	<0.001
Caucasian (frequency %)	205 (84.0)	883 (83.5)	736 (83.7)	623 (86.0)	<0.001
African American (frequency %)	7 (2.9)	33 (3.1)	39 (4.4)	51 (7.0)	<0.001
Latino (frequency %)	11 (4.5)	22 (2.1)	19 (2.2)	24 (3.3)	<0.001
Other ethnicity (frequency %)	21 (8.6)	119 (11.3)	85 (9.7)	27 (3.6)	<0.001
Median PSA at diagnosis (IQR)	5.1 (4.2–6.5)	4.9 (3.9–6.6)	5.5 (4.3–7.6)	5.3 (3.6–7.8)	<0.001
NCCN risk (frequency %)					<0.001
Very low/low risk	246 (56.3)	506 (47.5)	224 (24.3)	68 (9.3)	
Favorable inter risk	83 (19.0)	208 (19.5)	227 (24.7)	149 (20.4)	
Unfavorable inter risk	74 (16.9)	242 (22.7)	259 (28.2)	253 (34.7)	
High/very high risk	31 (7.1)	101 (9.5)	204 (22.2)	256 (35.1)	
NCCN risk unavailable; missing data	3 (0.7)	8 (0.8)	6 (0.7)	4 (0.5)	
Surgery after AS (frequency %)	0 (0)	48 (4.5)	76 (8.3)	232 (7.5)	<0.001
Median operative time (IQR)	199 (169–242)	167 (144–193)	185 (155–216)	213 (170–242)	<0.001
Median robot time in minutes (IQR)	157 (131–200)	129 (109–152)	146 (120–176)	173 (134–200)	<0.001
Median length of stay in days (IQR)	2 (1–2)	1 (1–2)	1 (1–1)	1 (1–1)	<0.001
Bilateral nerve spare (frequency %)	318 (72.8)	781 (73.8)	606 (67.1)	455 (63.7)	<0.001
Very low/low risk	203 (82.5)	462 (91.8)	208 (95.4)	61 (92.4)	<0.001
Favorable inter risk	64 (77.1)	161 (77.8)	184 (82.5)	132 (89.5)	0.029
Unfavorable inter risk	40 (54.1)	133 (55.2)	157 (61.6)	169 (67.9)	0.020
High/very high risk	9 (29.0)	21 (21.2)	53 (26.2)	91 (36.5)	0.018
NCCN risk unavailable; missing data	2	4	4	2	
90-day Clavien ≥ 3 complications (frequency %)	26 (5.9)	30 (2.8)	30 (3.3)	23 (3.2)	0.021
90-day urine leaks (frequency %)	10 (2.3)	1 (0.1)	4 (0.4)	1 (0.1)	<0.001
BNC requiring dilation (frequency %)	24 (5.5)	13 (1.2)	1 (0.1)	2 (0.3)	<0.001
Median follow-up months (IQR)	61 (46–92)	60 (17.5–84)	60 (26–77)	23 (12–36)	<0.001

Proportion given is the frequency divided by the total number of patients with available data at each time point

IQR Interquartile range, *PSA* Prostate-specific antigen, *AS* Active surveillance, *BNC* Bladder neck contracture

Table 2 Oncologic outcomes

	Cohort A	Cohort B	Cohort C	Cohort D	*P*
Pathologic gleason grade group					< 0.001
GG1 (frequency %)	167 (38.4)	296 (28.0)	128 (14.0)	41 (5.7)	
GG2 (frequency %)	188 (43.2)	513 (48.5)	469 (51.4)	360 (50.2)	
GG3 (frequency %)	52 (12.0)	171 (16.2)	202 (22.1)	194 (27.1)	
GG4 (frequency %)	13 (3.0)	34 (3.2)	38 (4.3)	29 (4.0)	
GG5 (frequency %)	15 (3.4)	43 (4.1)	74 (8.1)	93 (13.0)	
Upgrade-biopsy grade group to pathologic grade group	144 (33.2)	373 (35.4)	269 (29.6)	138 (19.3)	< 0.001
Pathologic T3 or T4 (frequency %)	71 (16.2)	256 (24.1)	293 (32.1)	330 (45.5)	< 0.001
Stage migration—clinical stage to pathologic stage	68 (15.6)	238 (22.5)	284 (31.4)	317 (43.8)	< 0.001
Positive margins (frequency %)	147 (34.3)	236 (22.5)	181 (19.9)	219 (30.4)	< 0.001
Positive margins with ≥ T3 disease (frequency %)	32 (47.1)	120 (47.2)	95 (32.4)	142 (43.3)	0.002
LND performed (frequency %)	165 (39.1)	657 (61.7)	684 (74.3)	672 (92.1)	< 0.001
Lymph node-positive* (frequency %)	2 (1.2)	12 (1.8)	58 (8.5)	97 (14.4)	< 0.001
1-year BCR (frequency %)	9 (3.5)	29 (3.9)	76 (9.7)	101 (19.2)	< 0.001
3-year BCR (frequency %)	29 (13.2)	52 (8.4)	124 (19.7)	50 (26.0)	< 0.001
5-year BCR (frequency %)	28 (19.2)	73 (15.4)	103 (23.2)	–	0.045
Adjuvant treatment (frequency %)	1 (0.3)	8 (0.8)	13 (1.4)	11 (1.5)	0.025
Salvage treatment ever (frequency %)	53 (14.6)	120 (11.3)	168 (18.3)	164 (22.5)	< 0.001

GG Grade Group, *LND* Lymph node dissection, *BCR* Biochemical recurrence

*Percentage of patients with positive lymph nodes out of those who underwent LND

Proportion given is the frequency divided by the total number of patients with available data at each time point

patients; and BNC occurred in 5.5%, 1.2%, 0.1%, and 0.3% of patients, respectively.

Oncologic outcomes

Oncologic outcomes are summarized in Table 2. Pathologic grade and T stage changed significantly over time, with cohort A having the lowest proportion of higher risk patients (6.4% GG4 or GG5 and 16.2% pT3 or pT4, $p < 0.001$) and cohort D having the highest proportion of higher risk patients (17% GG4 or GG5 and 45.5% pT3 or pT4, $p < 0.001$). Positive margin rates were 34.3%, 22.5%, 19.9%, and 30.4% in cohorts A, B, C, and D, respectively ($p < 0.001$). When evaluating patients with only pT3 or pT4 disease, the positive margin rates showed improvement with time (47.1%, 47.2%, 32.4%, and 43.3% in cohorts A, B, C, and D respectively, $p = 0.002$). Patients with lymph node-positive disease identified in final pathology increased from 1.2% in cohort A to 14.4% in cohort D. The 3-year BCR rates in cohorts A, B, C, and D were 13.2%, 8.4%, 19.7%, and 26.0%, respectively.

Table 3 Quality of Life Outcomes

	Cohort A	Cohort B	Cohort C	Cohort D	*P*
Baseline continent	98.0% (249/254)	99.4% (849/854)	100.0% (830/830)	98.9% (639/649)	< 0.001
Continent at 6 months	58.6% (92/157)	92.3% (619/671)	91.1% (533/585)	91.6% (348/380)	< 0.001
Continent at 1 year	74.8% (196/262)	93.9% (641/683)	94.4% (607/643)	92.4% (387/419)	< 0.001
Baseline potent	84.2% (224/266)	81.0% (720/890)	76.5% (614/803)	71.6% (464/648)	< 0.001
Potent at 6 months	37.8% (59/156)	45.5% (304/668)	41.0% (231/563)	34.7% (131/377)	0.022
Potent at 1 year	56.2% (146/260)	54.4% (387/712)	49.6% (314/633)	42.8% (178/416)	< 0.001
Maintained potency at 1 year	55.3% (84/152)	64.5% (314/487)	61.7% (280/454)	56.3% (160/284)	0.065
Potent at 1 year (bilateral nerve spare)	64.8% (125/193)	63.9% (331/518)	58.7% (257/438)	52.4% (142/271)	0.008

All data are self-reported; Proportion given is the number endorsing divided by the total number of patients reporting at each time point

Quality of life outcomes

Quality of life (QoL) outcomes are summarized in Table 3. Six-month continence significantly improved from 58.6% in cohort A to 92.3%, 91.1%, and 91.6% in cohorts B, C, and D respectively ($p < 0.001$), with similar rates at 1 year. Baseline potency decreased with each cohort from 84.2% in cohort A to 71.6% in cohort D ($p < 0.001$); and bilateral nerve spare also decreased with time from 72.8% in cohort A to 63.7% in cohort D ($p < 0.001$). In cohorts A, B, C, and D, the 6-month potency rates were 37.8%, 45.5%, 41.0%, and 34.7% ($p = 0.022$) and 1-year potency rates were 56.2%, 54.4%, 49.6%, and 42.8% ($p < 0.001$), respectively. When evaluating only patients who were potent at baseline, no significant differences were observed in potency at 1 year after surgery for patients receiving bilateral nerve sparing, unilateral nerve sparing, or non-nerve sparing procedures (see Table 3).

Discussion

The data presented here reflect two decades of experience treating prostate cancer. Our results illustrate the changes that have occurred over the course of a single surgeon's experience with a novel therapeutic option that quickly evolved into the standard of care. We noted significant changes over time in the clinical characteristics of patients undergoing surgery as well as perioperative, oncologic, and quality of life outcomes.

Over the past 20 years, national guidelines have changed significantly and these changes have occurred concomitantly with advancements in technologies and shifts in treatment strategies. For example, in 2012, the US Preventative Services Task Force (USPSTF) recommended against widespread PSA screening, a change that has contributed to the presentation of prostate cancer in later stages of disease [14]. This period also saw the introduction of guidelines in 2010 advocating for the adoption of active surveillance (AS) as the preferred management for low-risk prostate cancers. Subsequently its use for low-risk patients increased from 14.5% to 42.1% 5 years later [15]. These trends are reflected in our study, with the proportion of patients with GG4-5 cancer as well as pT3 or greater disease tripling from cohort A to cohort D, and the steady increase in patients having surgery after a period of AS over time.

Strategies for the detection and management of recurrent disease have also changed significantly over the study period. One of the first significant changes was the introduction of hypersensitive PSA. Introduced in the late 1990s, the use of hypersensitive PSA was widely adopted throughout the 2000s [16]. The higher rates of BCR seen in our later cohorts could have reflected the increasing availability of hypersensitive PSA. The post-operative management of prostate cancer has also been influenced by changes in the AUA/SUO adjuvant and salvage radiation guidelines, initially introduced in 2013 and then amended in 2018 and 2019 [17]. These changes render it challenging to interpret the rates of biochemical recurrence and salvage treatment that we noted in this report. As we generally did not offer salvage treatment for a PSA < 0.2 prior to 2010, before the changes described above which occurred in the 2000s, we did see a decrease in 5-year BCR, and in the "ever" use of salvage treatment between cohort A and B. Subsequently the rates of BCR, as well as those of salvage and adjuvant treatment, increased in cohorts C and D. Higher stage and grade are well-established risk factors for BCR [18, 19], and the much larger share of higher risk patients seen in latter cohorts here certainly contributes to the observed shift in BCR rates.

Positive surgical margins (PSM) are an important pathologic parameter for prostate cancer. Rates of positive margins range from 4% to 45% for all patients and could be as high as 24–80% for patients with T3 or higher disease [20, 21]. Risk factors for PSM include tumor stage and grade, tumor volume, PSA level, surgical experience, and pathologic processing [20]. While positive surgical margins confer a two–fourfold increased risk of biochemical recurrence, up to 80% of patients with a PSM may not suffer a recurrence [21]. In our study, rates of PSM fall within the range reported previously in the literature. We noted an initial decline in PSM rates from 34.3% in cohort A to 19.9% in cohort C, with a recent jump in cohort D to 30.4%. However, this is accompanied by a significant increase in the rate of extraprostatic disease (T3 +) in cohort D to 45.5% (Table 2) and increasing NCCN risk stratification (Table 1). We suspect the increasing risk stratification in men undergoing prostatectomy is due to the increased acceptance of active surveillance and perhaps due to changing USPSTF recommendations concerning prostate cancer screening, which have been shown to impact pathologic outcomes after prostatectomy. When evaluating PSM rate only among the patients with T3 or T4 disease, we saw an initial improvement from 47% in cohorts A and B to 32% and 43% in cohorts C and D, which we feel likely reflects improvements in surgical technique and preoperative imaging (such as more widespread use of MRI, PSMA PET CT, etc.) to aid in surgical planning.

Operative times (OT) are often correlated with increased risk of complications and use of resources, and it is of benefit to the healthcare system to reduce the time spent in the operating room. Initially, OT decreased from cohort A to cohort B and then increased in later cohorts. The initial decline was likely related to surgeon learning curve, consistent with the literature [22]. The increase in later cohorts was likely due to multiple causes. During the corresponding time period, trainee involvement in RALP increased as we initiated a minimally invasive urologic oncology fellowship at our institution. We have previously shown that an increase in resident/fellow involvement is associated with an increase in OT, but that these changes do not compromise patient safety or oncologic outcomes [23]. An increase in the presentation of higher stage disease over time necessitated increasing use of (and extent of) lymph node dissection in accordance with AUA guidelines [19], which was reflected in our increasing use of lymphadenectomy over time. The decision to perform a limited pelvic node dissection (obturator nodes) was initially by the patient's cancer risk factors and safety factors such as surgical time. This practice gradually morphed to an extended pelvic lymphadenectomy (ePLND) performed for patients with a ≥ 2% risk of nodal involvement. This practice change is supported by increasingly mounting evidence of the benefit of ePLND on BCR-free survival for higher risk patients [24]. Most recently, we have also begun to more routinely utilize peritoneal interposition flaps (PIF) to avoid the post-surgical formation of symptomatic lymphoceles [25]. Thus, the increasing OT in the more recent cohorts reflects advancements in surgical approach (in the case of ePLND and PIF) as well the strengthening of surgical education at our institution over time (in the case of increasing trainee involvement).

Quality of life outcomes after surgery are a very important consideration for patients and surgeons. Approximately half of patients rank avoidance of side effects as among their chief concerns when considering treatment options for localized prostate cancer [26]. In the HAROW study of localized prostate cancer treatment, QoL outcomes were among the most important drivers of patient decision regret, with erectile function (OR 3.2), active decision-making role (OR 2.2), urinary continence (OR 1.8), and freedom from recurrence (OR 1.6) predicting lower decision regret [27]. In our study, urinary continence improved from cohort A to B; this improvement was sustained for the remainder of the study period. We suspect this is secondary to both the learning curve and a transition from an interrupted to a running anastomosis in 2004. Potency improved initially but subsequently declined. These trends were accompanied by decreasing baseline potency and decreasing use of nerve sparing approaches, consistent with the worsening stage migration previously discussed. The rates of bilateral nerve sparing procedures for very low/low NCCN risk men did not change during our study. That these factors were key in the apparent cohort differences in potency at one year is supported by a series of analyses of potency at one year among subgroups of men, all potent at baseline and separated by nerve sparing status; there were no indications of a cohort effect for potency among those receiving bilateral ($p = 0.419$), unilateral ($p = 0.399$), or non-nerve sparing ($p = 0.676$) surgeries. We also saw a sustained decrease in complications over time, with Clavien ≥ 3 complications, anastomotic urine leaks, and bladder neck contractures all improving from a high in Cohort A, consistent with increasing surgeon experience as well as advances in techniques and equipment.

Limitations of the paper are largely addressed above. It is important to note that during the last 20 years, there have been many developments in both technology and technique that may be at play in these results. For instance, the three-arm standard da Vinci system used in 2001 is significantly different from the current 4-arm daVinci Xi system. We, like most surgical teams, are always striving to improve our results and have examined things, such as anterior suspension sutures, a Rocco stitch, a barbed versus smooth suture, etc. over the years. The duration of the postoperative Foley catheter was initially 14 days (too long), gradually decreased to 4 days after a cystogram (too short due to retention from anastomotic edema), and increased to 7 days without a cystogram. The differences in patient population that were observed over the course of the study add complexity to the interpretation of between-group comparisons. The single-surgeon series also has limitations to generalizability beyond the experience of a single high-volume surgeon. We were not able to randomize patients to treatment groups, and the study was subject to the drawbacks characteristic of retrospective chart review. Some patients were seen by their primary urologist after the immediate postoperative period and thus longer-term recurrence data are likely incomplete. Strengths of the paper include the relatively large patient cohort made possible by the long duration of the data collection.

Conclusions

Over the course of 20 years, complication rates and continence have improved for patients undergoing RALP over time. Patients had more aggressive and advanced cancer at the time of surgery, were older and had higher rates of erectile dysfunction at baseline. Operative times, positive surgical margin rates, and biochemical recurrence rates all initially declined, but subsequently increased in light of grade/stage migration to more advanced disease. Despite the significant confounds introduced by changes in technology and national guideline policies, we feel that this study provides valuable insight into the changing landscape of prostate cancer treatment over the past two decades.

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Data availability Data could be made available upon request to the corresponding author.

References

1. *Prostate Cancer Statistics*. (2022). Retrieved February 8 2022 from https://www.cancer.org/cancer/prostate-cancer/about/key-statistics.html#references
2. Binder J, Kramer W (2001) Robotically-assisted laparoscopic radical prostatectomy. BJU Int 87(4):408–410. https://doi.org/10.1046/j.1464-410x.2001.00115.x
3. Coughlin GD, Yaxley JW, Chambers SK et al (2018) Robot-assisted laparoscopic prostatectomy versus open radical retropubic prostatectomy: 24-month outcomes from a randomised controlled study. Lancet Oncol 19(8):1051–1060. https://doi.org/10.1016/s1470-2045(18)30357-7
4. Sammon JD, Karakiewicz PI, Sun M et al (2013) Robot-assisted versus open radical prostatectomy: the differential effect of regionalization procedure volume and operative approach. J Urol 189(4):1289–1294. https://doi.org/10.1016/j.juro.2012.10.028
5. Pilecki MA, McGuire BB, Jain U et al (2014) National multi-institutional comparison of 30-day postoperative complication and readmission rates between open retropubic radical prostatectomy and robot-assisted laparoscopic prostatectomy using NSQIP. J Endourol 28(4):430–436. https://doi.org/10.1089/end.2013.0656
6. Stolzenburg JU, Holze S, Neuhaus P et al (2021) Robotic-assisted versus laparoscopic surgery: outcomes from the first multicentre, randomised, patient-blinded controlled trial in radical prostatectomy (LAP-01). Eur Urol 79(6):750–759. https://doi.org/10.1016/j.eururo.2021.01.030
7. McAlpine K, Forster AJ, Breau RH et al (2018) Robotic surgery improves transfusion rate and perioperative outcomes using a broad implementation process and multiple surgeon learning curves. Canadian Urol Assoc J. https://doi.org/10.5489/cuaj.5527
8. Sivaraman A, Sanchez-Salas R, Prapotnich D et al (2017) Learning curve of minimally invasive radical prostatectomy: comprehensive evaluation and cumulative summation analysis of oncological outcomes. Urol Oncol 35(4):149.e141-149.e146. https://doi.org/10.1016/j.urolonc.2016.10.015
9. Chang P, Szymanski KM, Dunn RL et al (2011) 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 186(3):865–872. https://doi.org/10.1016/j.juro.2011.04.085
10. Litwin MS, Hays RD, Fink A et al (1998) The UCLA Prostate Cancer Index: development, reliability, and validity of a health-related quality of life measure. Med Care 36(7):1002–1012. https://doi.org/10.1097/00005650-199807000-00007
11. Sacco E, Prayer-Galetti T, Pinto F et al (2006) 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 97(6):1234–1241. https://doi.org/10.1111/j.1464-410X.2006.06185.x
12. Ficarra V, Novara G, Ahlering TE et al (2012) Systematic review and meta-analysis of studies reporting potency rates after robot-assisted radical prostatectomy. Eur Urol 62(3):418–430. https://doi.org/10.1016/j.eururo.2012.05.046
13. Jackson MA, Bellas N, Siegrist T et al (2016) Experienced open vs early robotic-assisted laparoscopic radical prostatectomy: a 10-year prospective and retrospective comparison. Urology 91:111–118. https://doi.org/10.1016/j.urology.2015.12.072
14. Butler SS, Muralidhar V, Zhao SG et al (2020) Prostate cancer incidence across stage, NCCN risk groups, and age before and after USPSTF Grade D recommendations against prostate-specific antigen screening in 2012. Cancer 126(4):717–724. https://doi.org/10.1002/cncr.32604
15. Mahal BA, Butler S, Franco I et al (2019) 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 321(7):704–706. https://doi.org/10.1001/jama.2018.19941
16. Furubayashi N, Negishi T, Kashiwagi E et al (2014) Usefulness of ultra-sensitive prostate-specific antigen following radical prostatectomy. Mol Clin Oncol 2(5):851–857. https://doi.org/10.3892/mco.2014.310
17. Pisansky TM, Thompson IM, Valicenti RK et al (2019) Adjuvant and salvage radiotherapy after prostatectomy: ASTRO/AUA guideline amendment 2018–2019. J Urol 202(3):533–538. https://doi.org/10.1097/ju.0000000000000295
18. Ahove DA, Hoffman KE, Hu JC et al (2010) Which patients with undetectable PSA levels 5 years after radical prostatectomy are still at risk of recurrence?–implications for a risk-adapted follow-up strategy. Urology 76(5):1201–1205. https://doi.org/10.1016/j.urology.2010.03.092
19 Sanda MG, Cadeddu JA, Kirkby E et al (2018) Clinically localized prostate cancer: AUA/ASTRO/SUO guideline. Part II: recommended approaches and details of specific care options. J Urol 199(4):990–997. https://doi.org/10.1016/j.juro.2018.01.002
20. Fleshner NE, Evans A, Chadwick K et al (2010) Clinical significance of the positive surgical margin based upon location, grade, and stage. Urol Oncol Sem Original Invest 28(2):197–204. https://doi.org/10.1016/j.urolonc.2009.08.015
21. Pettenati C, Neuzillet Y, Radulescu C et al (2015) Positive surgical margins after radical prostatectomy: what should we care about? World J Urol 33(12):1973–1978. https://doi.org/10.1007/s00345-015-1580-x
22. Hashimoto T, Yoshioka K, Gondo T et al (2013) Learning curve and perioperative outcomes of robot-assisted radical prostatectomy in 200 initial Japanese cases by a single surgeon. J Endourol 27(10):1218–1223. https://doi.org/10.1089/end.2013.0235
23. Baber J, Staff I, McLaughlin T et al (2019) Impact of urology resident involvement on intraoperative, long-term oncologic and functional outcomes of robotic assisted laparoscopic radical prostatectomy. Urology 132:43–48. https://doi.org/10.1016/j.urology.2019.05.040
24. Lestingi JFP, Guglielmetti GB, Trinh Q-D et al (2021) Extended versus limited pelvic lymph node dissection during radical prostatectomy for intermediate- and high-risk prostate cancer: early oncological outcomes from a randomized phase 3 trial. Eur Urol 79(5):595–604. https://doi.org/10.1016/j.eururo.2020.11.040
25. Lee M, Lee Z, Eun DD (2020) Utilization of a peritoneal interposition flap to prevent symptomatic lymphoceles after robotic radical prostatectomy and bilateral pelvic lymph node dissection. J Endourol 34(8):821–827. https://doi.org/10.1089/end.2020.0073
26. Zeliadt SB, Moinpour CM, Blough DK et al (2010) Preliminary treatment considerations among men with newly diagnosed prostate cancer. Am J Manag Care 16(5):e121-130
27. Baunacke M, Schmidt ML, Groeben C et al (2020) Decision regret after radical prostatectomy does not depend on surgical approach: 6-Year followup of a large German cohort undergoing routine care. J Urol 203(3):554–561. https://doi.org/10.1097/ju.0000000000000541