Robotic Radical Prostatectomy: Operative Technique, Outcomes, and Learning Curve

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ABSTRACT

Objective: To report the operative technique, oncologic and therapeutic outcomes, and learning curve from our initial series of over 140 patients treated by robotic radical prostatectomy.

Methods: Between January 2003 and May 2005, 143 patients with clinically localized prostate cancer underwent a robotic radical prostatectomy. Prospective data collection included patient age, body mass index (BMI), clinical T stage, biopsy Gleason score, and prostate-specific antigen (PSA). Operative outcome measures included operative time, estimated blood loss (EBL), and complications. Post-operative outcomes were length of hospital stay, catheter duration, pathology, margin status, biochemical recurrence, and return of continence.

Results: Mean operative time was 241 minutes with an EBL of 274 mL. Five patients (3%) required conversion to open surgery. The average hospitalization was 1.8 days, and Foley catheters were removed after 8.9 days. Twenty-four of 141 men (17%) had a positive surgical margin, with a decrease from 23% in the first half of our experience to 11% in the latter half. Patients with an extracapsular extension had a significantly higher positive surgical margin rate than did those with organ-confined disease (47% vs 15%). Over 40% of the positive margins were located posteriorly. At a mean follow-up of 11 months, 96% of patients had a PSA < 0.2 ng/mL. The median time to complete continence was 3.5 months, and over 95% of patients were fully continent at 1 year.

Conclusion: Robotic radical prostatectomy is an effective treatment modality for clinically localized prostate cancer. Although a learning curve needs to be overcome, patients experienced benefits in convalescence with early oncologic and functional outcomes comparable to those of the open approach. Longer-term results are needed; however, patient outcomes in our series are encouraging.

Key Words: Robotic radical prostatectomy, Prostate cancer, Urologic oncology, Operative techniques, Learning curve.

INTRODUCTION

Since the initial description by Walsh and Donker in 1982 regarding the anatomic basis for erectile function, urologists have continuously explored technical advances that would improve both the oncologic and quality of life outcomes following radical prostatectomy. Anatomical nerve-sparing methods have become mainstream practice with resultant improvements in erectile function rates following what was once considered a morbid procedure. Although some interval modifications have been achieved in the radical retropubic prostatectomy operation, the next most significant advancement in surgical technique has been the introduction of laparoscopy. In the late 1990s, Guillonneau and Vallancien introduced laparoscopic radical prostatectomy as a viable surgical alternative for treating prostate cancer. Subsequently, several centers have gone on to incorporate laparoscopic prostatectomy into their surgical armamentarium with successful outcomes. Having set the stage for laparoscopy in the surgical treatment of prostate cancer, urologists then sought to improve upon such techniques with the use of robotics and the implementation of robotic radical prostatectomy. Throughout the evolution of technology and treatment strategies, the urologic community has stringently emphasized the need to demonstrate both oncologic and therapeutic efficacy of procedures. The acceptance of changes in surgical technique has always been predicated by demonstrable evidence from multiple institutions, regarding both the clinical and pathologic criteria that are essential for the successful treatment of prostate cancer. As such, we have entered the robotic age in the treatment of prostate cancer with encouraging reports from a few centers of excellence.
Here then, we hope to further diversify the experience in robotic prostatectomy and enrich the confidence of treating urologists by reporting our operative technique, oncologic and therapeutic outcomes, and learning curve from our initial series of over 140 consecutive patients treated by robotic radical prostatectomy.

METHODS

Patient Selection

Between January 2003 and May 2005, 174 consecutive patients with clinically localized prostate cancer underwent a robotic radical prostatectomy performed by 2 surgeons (DSS and DS) at the New York-Presbyterian Hospital. Thirty-one patients with a follow-up period of less than 3 months were excluded from analysis in this study. The remaining 143 patients were then analyzed for the purposes of assessing outcomes. All patients had biopsy proven adenocarcinoma of the prostate and were staged according to the 2002 American Joint Committee on Cancer (AJCC) classification.12

Operative Technique

All patients underwent a robotic radical prostatectomy with the da Vinci surgical system (Intuitive Surgical Inc., Sunnyvale, CA). The procedure was performed as described by Menon et al11 with a few modifications.

Briefly, following induction of general endotracheal anesthesia, the patient was placed in the lithotomy position with a steep Trendelenberg. The abdominal and groin areas were prepped and draped, intravenous antibiotics were administered before skin incision, and a 20-F, 30-cc urethral catheter was placed. A 1.5-cm incision was made to the left of the umbilicus, and a Veress needle was used to insufflate the abdomen with CO2 to a pressure of 15cm H2O. A 10/12-mm trocar for the camera was placed at the umbilicus, two 8-mm trocars for the robotic arms were placed just lateral to the medial umbilical ligaments, a 5-mm suction port was introduced to the right of the umbilicus, and 10/12-mm and 5-mm trocars were introduced 2 fingerbreadths above the iliac crest on the patient’s right and left side, respectively. Overall, 6 ports were used, and the da Vinci robot was docked.

Starting with a 30° angle-up lens, the medial umbilical ligaments were incised up the anterior abdominal wall allowing cephalad reflection of the bladder and entry into the space of Retzius. The adipose tissue overlying the endopelvic fascia was cleared. The lens was changed to a 0° angle, and the endopelvic fascia was opened in a cautery-free manner to expose the apex of the prostate. The levator muscles were swept posterolaterally, and the puboprostatic ligaments were sharply divided to gain further length beyond the apex of the prostate. The superficial and deep dorsal veins were ligated with a 0-vicryl stitch, and a second 0-vicryl stitch was then placed for back bleeding over the anterior surface of the prostate.

The 30° angle-down lens was used for the bladder neck dissection. The anterior bladder neck was divided, and the ureteral orifice position and presence of a median lobe were assessed, and then the posterior bladder neck was divided. The vas deferens and seminal vesicles were then identified. The vasa were divided and the seminal vesicles were dissected in a cautery-free manner to avoid potential injury to the neurovascular bundles. The posterior layer of Denonvillier’s fascia was divided allowing for identification of perirectal fat, which served as a guide between the prostate and rectum. To optimize nerve sparing, all prostatic pedicles were clipped and sharply divided without using electrocautery. The lateral prostatic fascia was incised on each side allowing the neurovascular bundles to fall posterolaterally, and a bilateral nerve-sparing procedure was performed when possible.

The neurovascular bundle was released distally to the level of the urethra and prostatic apex. At this point, the only remaining attachments of the prostate were the dorsal vein complex (DVC) and the urethra. The DVC and urethra were then divided rendering the prostate free, and the specimen was placed in a 10-mm endocatch bag. Intraoperative frozen sections was used judiciously to help decrease the incidence of positive surgical margins.

The urethrovessical anastomosis was performed in a running fashion by using a double-arm 2–0 Monocryl suture. An 18-Fr, 10-mL urethral catheter was placed and irrigated to ensure a water-tight anastomosis. A bilateral pelvic lymph node dissection was performed following completion of the urethrovessical anastomosis in patients with a greater than 2% chance of positive lymph nodes as obtained from the Partin predictive tables. Borders of the node dissection were the external iliac vein anteriorly, obturator nerve posteriorly, bifurcation of common iliac artery superiorly, and Cooper’s ligament inferiorly. A #10 flat JP drain was placed into the pelvis and brought out through the left-side 5-mm port. The da Vinci robot was then undocked, all trocars were removed under direct vision, and the specimen was removed through the camera port. The fascia at the extraction site was closed with
a 2–0 vicryl suture, and all skin incisions were closed with a 4–0 Biosyn stitch.

**Follow-up**

Patients were seen approximately 1 week postoperatively for catheter removal. Cystograms were not routinely obtained before catheter removal. Postoperative PSA values, urinary continence, and erectile function were evaluated 6 weeks postoperatively, every 3 months for the first year, every 6 months for the second year, and yearly thereafter.

**Data collection, Outcomes, and Statistical Analysis**

Before surgery, all men were evaluated with the following data recorded: age, BMI, clinical T stage, biopsy Gleason score, and prostate-specific antigen (PSA). Operative outcome measures included operative time, estimated blood loss (EBL), and complications. Postoperative outcomes were length of hospital stay, catheter time, pathology, margin status, biochemical recurrence, and return of continence. The chi-square ($\chi^2$) log-rank test with the Yates correction factor and the unpaired 2-tailed Student $t$ test were used to compare variables between the first and second 70 patients in our series.

**RESULTS**

The demographic data of the patient population are summarized in Table 1. Table 2 outlines the operative data from our series of patients. The mean operative time was 241 minutes (range, 120 to 540), with a decrease of over 100 minutes when comparing our initial series of 70 with our more recent 70 patients (318 vs 209, $P<0.001$). The mean estimated blood loss (EBL) was 274 mL (range, 10 to 800), with a significant decrease in our more recent series of patients (387 vs 155, $P<0.001$). In 127 men, data regarding nerve sparing were available. One hundred and nine of 127 men (86%) had a bilateral nerve-sparing operation, whereas 13/127 (10%) had unilateral nerve-sparing, and 5/127 (4%) had bilateral nerve resections. Sixty-six of the last 70 patients (94%) had bilateral nerve-sparing operations. Two individuals underwent robotic-assisted genitofemoral nerve grafts. Five patients (3%) had a conversion to open surgery for bleeding,1 large intravesical median lobes,2 adherence to the rectum,1 and robot malfunction.1 Only 1 of our last 70 patients (1%) required an open conversion.

Table 3 summarizes the postoperative data. The mean hospital stay was 1.8 days (range, 1 to 10). Of our most recent 70 patients, 65 (93%) were discharged within 24 hours of surgery. The urethral catheter was removed at a mean time of 8.9 days (range, 1 to 29). At a mean follow-up of 11 months, 96% of patients (137/143) had a PSA <0.2 ng/mL. Four patients had postoperative complications including an ileus,2 small bowel obstruction1 requiring reoperation, and a urethral stricture1 requiring repeat dilatation.

Table 4 outlines the postoperative pathology data across our cohort of patients. Two patients (1%) did not have any tumor identifiable in the final pathology specimen, 1 of whom received preoperative hormonal deprivation therapy. Organ-confined (OC) disease (pT2) was present in 122/141 patients (87%) and extracapsular extension (ECE) was present in the final pathology analysis (pT3/T4) of 19/141 (13%) patients. Twenty-four of 141 men (17%) in our series had a positive margin on examination of the specimen, with a decrease from 23% (16/70) to 11% (8/70) when comparing our more recent 70 patients with the initial 70 ($P=0.07$). Patients with ECE had a significantly higher rate of positive surgical margins than did those with OC disease (47% vs 12%, $P<0.001$). When exclusively considering pT3 disease, we further noted a decrease in positive margins when comparing our first 70 patients (5/9; 56%) with our latter 70 (2/8; 25%). No significant difference existed in positive margin rates in the Gleason ≤7 cohort (19/122, 16%) and the Gleason >7 group (4/19, 21%) ($P=0.55$). Over 40% (14/33) of the positive margins were located in the posterior aspect of

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**Table 1.**

Demographic Data

| No. Patients | 143 |
| Age (range) | 60.4 (43–75) |
| BMI (kg/m²) (range) | 26.8 (18–38) |
| Serum PSA (ng/mL) (range) | 6.7 (1–60) |
| Gleason Score (%) | |
| 5 | 1 (1) |
| 6 | 75 (52) |
| 7 | 53 (37) |
| 8 | 9 (6) |
| 9 | 5 (4) |

| No. Clinical Stage (%) | |
| T1c | 97 (67) |
| T2a | 44 (31) |
| T2b | 2 (2) |

| Family History of Prostate Cancer (%) | 16 (11) |

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1. JSLS (2007)11:1–7
the prostate. The number of positive apical, anterior, and posterior positive margins remained unchanged as experience matured in this series; however, margin positivity at the bladder neck decreased from 7 in the first cohort of patients to 2 in our latter operative experience.

Table 2.
Operative Data

|                              | P Value* |
|------------------------------|----------|
| Operative Duration (mins) (range) |          |
| Overall                      | 241 (120–540) | <0.001 |
| First 70                     | 318 (150–540) |        |
| Second 70                    | 209 (120–474) |        |
| Estimated Blood Loss (mL) (range) |          |
| Overall                      | 274 (10–1800) | <0.001 |
| First 70                     | 387 (50–1800) |        |
| Second 70                    | 155 (10–600)  |        |
| Nerve Sparing† (%)           |          |
| Bilateral                    | 109 (86)   |        |
| Unilateral                   | 13 (10)    |        |
| Non-nerve sparing‡           | 5 (4)      |        |
| Open Conversions (%)         |          |
| Overall                      | 5 (3)      | 0.17   |
| First 70                     | 4 (6)      |        |
| Second 70                    | 1 (1)      |        |

*Comparison of first 70 cases versus second 70 cases in series.
†Data available for 127 patients.
‡Two of these 5 patients underwent robotic genitofemoral nerve grafts.

Table 3.
Postoperative Data

|                              |          |
|------------------------------|----------|
| Mean Follow-up (mos) (range) | 11 (3–26) |
| Hospitalization Days (range) | 1.8 (1–10)|
| First 70                     | 1.9 (1–10)|
| Second 70                    | 1.1 (1–7 )|
| Days Foley Catheterization (range) | 8.9 (1–29) |
| Postop PSA <0.2 ng/mL (%)    | 96       |
| Postop Complications (%)     |          |
| Ileus                        | 2 (1)    |
| Bowel obstruction            | 1 (1)    |
| Urethral stricture           | 1 (1)    |

Table 4.
Pathologic Data

| Pathologic Stage | T0 (no tumor) | T2a | T2b | T2c | T3a | T3b | T4 |
|------------------|---------------|-----|-----|-----|-----|-----|----|
|                  | 2 (1)         | 15  | 24  | 83  | 12  | 5   | 2  |
| Gleason Score (%)| 5 (no tumor)  | 1   | 2   | 7   | 7   | 56  | 8  |
| Perineural Invasion (%) | 38 (27) |

| Location Total (1st 70/2nd 70)* | Apex | Bladder neck | Anterior | Posterior |
|---------------------------------|------|--------------|----------|-----------|
|                                 | 5    | 7            | 9 (7/2)  | 5 (3/2)   |
| Pos. Margins by Stage (%)       |      |              |          |           |
| pT2a                            | 2/15 (13)|            |          |           |
| pT2b                            | 0/24 (0)|            |          |           |
| pT2c                            | 13/83 (16)|           |          |           |
| pT3a                            | 5/12 (42)|            |          |           |
| pT3b                            | 2/5 (40)|            |          |           |
| pT4                             | 2/2 (100)|           |          |           |
| Pos. Margins by Gleason (%)     |      |              |          |           |
| ≤7                              | 19/122 (16)|          |          |           |
| >7                              | 4/19 (21)|            |          |           |

*Total number of positive margin sites identified in all specimens. Several patients had more than 1 site of positive margins.

Figure 1 graphically depicts the return of full urinary continence across the entire cohort. Patients requiring no urinary pads were considered continent, and the use of even one pad per day for occasional stress urinary incon-
continence was not considered continent for the purposes of our analysis. The median time to complete continence was 3.5 months, and over 95% of patients were fully continent at 1-year follow-up. Because our data are awaiting maturity, we will hold off on reporting potency data in this analysis.

**DISCUSSION**

As robotic surgery becomes a more accepted treatment modality for clinically localized prostate cancer, many urologists are struggling to incorporate this technique into their therapeutic armamentarium. Increasingly, surgeons are foregoing open retropubic approaches with a technically challenging robotic-assisted technique for which efficacy data are currently limited but growing. It is the intent of our analysis to objectively analyze the robotic approach from an oncologic standpoint, and in doing so, to characterize the oncologic and therapeutic efficacy of this relatively new and growing technology.

Although the ultimate measure of any intervention is the ability to prolong long-term survival, modifications in surgical technique can be assessed in the short-term by analyzing pertinent oncological principles. One such variable is pathology margin status. It is generally agreed that a positive margin is indicative of incomplete tumor resection and bears significant prognostic importance. Several institutions have demonstrated the independent prognostic significance of positive surgical margins across all stages of disease. Han et al further point out that the rate of positive surgical margins has declined dramatically from around 40% during the early 1980s to less than 10% more recently. Although these observations are likely multifactorial, the lower positive margin rates over the past decade are largely attributable to the stage migration that has occurred in the era of PSA screening. It is imperative, however, to also consider contemporary refinements in preoperative planning, biopsy strategies, and surgical technique. As we embark on the robotic age for the treatment of prostate cancer, it is essential that we adhere to surgical principles learned over the last 3 decades.

In this study, we report an overall positive margin rate of 17%. During the first half of our experience, we noted a 23% positive margin rate, which declined to 11% over our last 70 consecutive patients. Further, no difference existed in the pathologic distribution of tumors between our initial 70 patients and our latter 70 (9 vs 10 cases of ECE). Collectively, these data suggest that the decline in the positive margin rate is most attributable to an improved surgical skill set in the robotic technique rather than a decrease in the number of biologically aggressive tumors.
Subset analysis of the data also notes a significantly lower incidence of positive margins when comparing specimens with organ-confined disease with those with extracapsular extension (12% vs. 47%, P<0.001). Noteworthy, however, is the decrease in positive margin rates from 56% to 25% in the pT3 subgroup of tumors during the evolution of our experience. This underscores that robotic prostatectomy is a reasonable surgical alternative for organ-confined, as well as pT3 disease. Thus, even in our initial robotic experience, the results compare favorably with those of other reported robotic series, as well as with the current oncologic gold standard open retropubic approach.18,19

The specific location of positive margins is explainable both by surgical experience and technique. As depicted in Table 4, bladder neck positive margins declined over 3-fold when comparing the first half of our robotic experience and our most recent surgical series. The antegrade approach utilized during a robotic prostatectomy can be quite challenging and choosing the appropriate location for incision of the bladder neck can be difficult. As our experience in robotic surgery has matured, we have learned to take a wider bladder neck and robotically reconstruct the bladder as necessary. This modification has probably resulted in decreased positive bladder neck margins as our experience increased. In terms of the anterior and apical margins, we noted that 15% (5/33) of all positive margin sites were at each of these 2 anatomic locations, respectively. This compares favorably with other published reports in which the apical positive margin rates range from 5% to 28%.20 We believe that the anterior and apical dissection is enhanced with the robotic approach likely due to the use of an angled lens resulting in improved visualization of the dorsal vein/urethral complex.

At 1-year follow-up, 97% (139/143) of men were fully continent without the requirement of any pads. This compares favorably with continence data published following the open retropubic approach. Our 3-month follow-up data, however, indicate that less than 50% of patients are fully continent at this time point. Anecdotally, this is lower than the continence rates we have observed for our contemporary open retropubic prostatectomy series. One possible explanation is that the enhanced robotic visualization may result in excessive dissection of the striated sphincter complex beyond the apex of the prostate. To improve the early continence rates, we have made several modifications in our current technique including tacking the urethra to the periosteum of the pubis and avoiding excessive dissection beyond the apex of the prostate. With such modifications, our short-term continence rates have improved in a more contemporary group of patients (data not shown).

CONCLUSION

Robotic-assisted radical prostatectomy is an effective modality for the treatment of clinically localized prostate cancer. We acknowledge that a learning curve needs to be overcome; however, with a rigorous, focused robotic educational program, early oncologic functional results compare favorably with results of the open retropubic approach.

References:

1. Walsh PC, Donker PJ. Impotence following radical prostatectomy: insight into etiology and prevention. J Urol. 1982;128:492–497.
2. Catalona WJ. Nerve-sparing radical retropubic prostatectomy. Urol Clin North Am. 1985;12:187–199.
3. Guillonneau B, Vallancien G. Laparoscopic radical prostatectomy: the Montsouris experience. J Urol. 2000;163:418–422.
4. Su LM, Link RE, Bhayani SB, et al. Nerve-sparing laparoscopic radical prostatectomy: replicating the open surgical technique. Urology. 2004;64:123–127.
5. Basillote JB, Ahlering TE, Skarecky DW, Lee DI, Clayman RV. Laparoscopic radical prostatectomy: review and assessment of an emerging technique. Surg Endosc. 2004;18:1694–1711.
6. Ahlering TE, Skarecky D, Lee D, Clayman RV. Successful transfer of open surgical skills to a laparoscopic environment using a robotic interface: initial experience with laparoscopic radical prostatectomy. J Urol. 2003;170:1738–1741.
7. Menon M, Shrivastava A, Sarle R, Hemal A, Tewari A. Vattikuti Institute Prostatectomy: a single-team experience of 100 cases. J Endourol. 2003;17:785–790.
8. Patel VR, Tully AS, Holmes R, Lindsay J. Robotic radical prostatectomy in the community setting—the learning curve and beyond: initial 200 cases. J Urol. 2005;174:269–272.
9. Hoznek A, Menard Y, Salomon L, Abbou CC. Update on laparoscopic and robotic radical prostatectomy. Curr Opin Urol. 2005;15:173–180.
10. Herrell SD, Smith JA, Jr. Laparoscopic and robotic radical prostatectomy: what are the real advantages? BJU Int. 2005;95:3–4.
11. Menon M, Hemal AK. Vattikuti Institute prostatectomy: a technique of robotic radical prostatectomy: experience in more than 1000 cases. J Endourol. 2004;18:611–619.
12. Greene FL, American Joint Committee on Cancer, American
13. Han M, Partin AW, Pound CR, et al. Long-term biochemical disease-free and cancer-specific survival following anatomic radical retropubic prostatectomy. The 15-year Johns Hopkins experience. *Urol Clin North Am.* 2001;28:555–565.

14. Grossfeld GD, Chang JJ, Broering JM, et al. Impact of positive surgical margins on prostate cancer recurrence and the use of secondary cancer treatment: data from the CaPSURE database. *J Urol.* 2000;163:1171–1177, quiz 1295.

15. Hull GW, Rabbani F, Abbas F, Wheeler TM, Kattan NW, Scardino PT. Cancer control with radical prostatectomy alone in 1,000 consecutive patients. *J Urol.* 2002;167:528–534.

16. Han M, Partin AW, Chan DY, Walsh PC. An evaluation of the decreasing incidence of positive surgical margins in a large retropubic prostatectomy series. *J Urol.* 2004;171:23–26.

17. Scherr DS, Eastham J, Ohori M, Scardino PT. Prostate biopsy techniques and indications: when, where, and how? *Semin Urol Oncol.* 2002;20:18–31.

18. Ahlering TE, Eichel L, Edwards RA, Lee DI, Skarecky DW. Robotic radical prostatectomy: a technique to reduce pT2 positive margins. *Urology.* 2004;64:1224–1228.

19. Ohori M, Wheeler TM, Kattan MW, Goto Y, Scardino PT. Prognostic significance of positive surgical margins in radical prostatectomy specimens. *J Urol.* 1995;154:1818–1824.

20. Laven BA, Alsikafi NF, Yang XJ, Brendler CB. Minor modifications in apical dissection of radical retropubic prostatectomy in patients with clinical stage T2 prostate cancer reduce positive surgical margin incidence. *Urology.* 2004;63:95–98.