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Patel VR, Palmer KJ, Samavedi S Coughlin G

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Robotic-Assisted Laparoscopic Radical Prostatectomy: A Review of the Current State

K. J. Palmer, S. Samavedi, G. Coughlin, V. R. Patel

Abstract: Cancer of the prostate is the most common malignancy diagnosed in the male genitourinary tract. Although a number of treatment options are available for early prostate cancer, the gold standard of treatment remains retropubic radical prostatectomy (RRP). However, robotic-assisted laparoscopic radical prostatectomy (RALP) has become a forerunner in treatment options, yielding comparable medium-term perioperative and functional outcomes. For this our team utilized MEDLINE searching for publications on perioperative and functional outcomes related to robotic prostatectomy. Robotic-assisted prostatectomy has allowed urologists to enter the realm of minimally invasive surgery by incorporating open surgery manoeuvres to a laparoscopic environment. To date RALP perioperative and functional outcomes are comparable to the gold standard. Collection of long-term data is needed in order to establish its true efficacy.

Kurzfassung: Roboterassistierte laparoskopische radikale Prostatektomie: Ein Überblick über den aktuellen Stand. Prostatakrebs ist die häufigste bösartige Erkrankung des männlichen Urogenitaltrakts. Für Prostatakrebs im Frühstadium gibt es eine Reihe von Behandlungsmöglichkeiten, wobei der Goldstandard nach wie vor die radikale retropubische Prostatektomie (RRP) ist. Doch auch die roboterassistierte laparoskopische radikale Prostatektomie (RALP) hat sich zu einer wichtigen Behandlungsoption entwickelt, die zu vergleichbaren mittelfristigen, perioperativen und funktionellen Ergebnissen führt. Unser Team suchte in MEDLINE nach Publikationen über perioperative und funktionelle Ergebnisse im Zusammenhang mit der robotischen Prostatektomie. Die roboterassistierte Prostatektomie ermöglicht die Durchführung minimal invasiver Operationen in der Urologie, wobei Techniken der offenen Chirurgie in einer laparoskopischen Umgebung angewendet werden. Die bisherigen perioperativen und funktionellen Ergebnisse von RALP sind mit jenen des Goldstandard-Verfahrens vergleichbar. Um Aussagen über die tatsächliche Wirksamkeit treffen zu können, müssen jedoch noch langfristige Daten gesammelt werden. **J Urol Urogynäkol 2008; 15 (1): 14–20.**

Introduction

Cancer of the prostate is the most common malignancy of the male genitourinary tract and although a number of treatment options are available, radical prostatectomy remains the gold standard for long term cure (> 10 y) [1]. It was first described by H. H. Young in 1905 associated with significant intraoperative and perioperative morbidity [2].

The procedure has been developed over a century from the first radical prostatectomy in 1905 through the development of understanding of the surgical anatomy by Patrick Walsh in the 1980's to the current state [3–5]. At this time, open radical prostatectomy has become a refined procedure with acceptable cancer control rates and improved functional outcomes. However, this technique is challenging due to small confines of the pelvis and its associated higher surgical morbidity owing to a large abdominal incision, postoperative pain, need for strong narcotic pain medications and a prolonged recovery period as was reported in a patient complications survey: 30 % incontinence, 60 % erectile dysfunction and 20 % secondary surgical treatments for urethral strictures [6]. The combination of patients being diagnosed with less aggressive, lower stage disease and the potential morbidity associated with the open surgical approach has resulted in the search for less invasive surgical options.

Laparoscopic radical prostatectomy (LRP) was first described in 1991 as a potential minimally invasive surgical approach to remove the prostate [7]. The initial results were not encouraging; however, over a decade of refinement the technique developed significantly to become an acceptable surgical alternative. Laparoscopy provided certain key advantages not afforded by the open surgical approach, such as: magnified two-dimensional visualization, a pneumoperitoneum to decrease the blood loss and small surgical incisions to reduce the post surgical pain and recovery period. Thus, minimally invasive surgery has the potential to be of great benefit to patients needing prostate cancer surgery. While the technique has become more refined over a 15 year period, it has failed to become a part of mainstream urology. The limitations of laparoscopic prostatectomy are related to its steep learning curve (minimum of 50–100 cases) and long mean operative times, making it unrealistic for most surgeons. The first series of patients demonstrated no benefit when compared with the open approach regarding tumor removal, length of stay (LOS), convalescence, continence, potency or cosmesis [7]. However, since then multiple groups have reported their experiences with outcomes comparable to the former [8–11] (Table 1).

While the concept of a minimally invasive approach to prostatectomy was attractive, laparoscopic prostatectomy provided certain technical challenges that limited its feasibility, growth and overall rate of adoption. These limitations included two-dimensional vision, counterintuitive motion of the surgeon and non-wristed instrumentation. These challenges were magnified in the confines of the pelvis. It was believed that advances in surgical technology would be necessary to catapult laparoscopy into mainstream urology for prostatectomy. Robotic-assisted surgery has such a potential.

The daVinci Surgical System (Intuitive Surgical, Inc., Sunnyvale, California) is robotic-assisted laparoscopic surgery that provides certain advantages during laparoscopic surgery, to include: magnified 10X three-dimensional vision, motion scaling, tremor filtration, intuitive motion and wristed miniature instrumentation. These advantages were uniquely suited to the challenges of performing complex laparoscopic surgery.

The first robotic prostatectomy was performed in 2000 by Binder in Germany [20]. Subsequently, the procedure has undergone significant innovation and advancement. Initial results from the Henry Ford Hospital showing low operative times, limited patient morbidity and improved patient out-

Address for correspondence: Vipul R. Patel, M. D., Global Robotics Institute, 410 Celebration Place Suite 302, Celebration, FL 34747, USA, email: Vipul.patel.md@flhosp.org

Table 1. Comparative analysis with LRP series.

Author	Center	Year	No. Patients	Sx Route	Op time (mins)	EBL (ml)	BT	PLND	PSM	Comp Rate (%)	Freedom from Progression
Guillonneau [12]	Montsouris	2003	1000	TP	–	–	–	21.6 %	19.2 %	–	90.5 % at 3 years
Rassweiler [13]	Heilbronn	2005	500	TP	–	–	–	83.4 %	19 %	–	83 % at 3 years
Stolzenburg [14]	Leipzig	2005	700	EP	151	220	0.9 %	38 %	10.8 % T2 31.2 % T3	9.7	–
Gonzalgo [15]	John Hopkins	2005	250	TP	–	–	2.8 %	–	–	13.8	–
Rozet [16]	Montsouris	2005	600	EP	173	380	1.2 %	18 %	17.7 %	11.5	95 % at 1 year
Rassweiler [17]	German multicenter	2006	5824	TP + EP	196	–	4.1 %	68 %	10.6 % T2 32 % T3a 56 % T3b	8.9	–
Eden [18]	North Hampshire	2006	100	TP	245	313	3 %	14 %	16 %	11	89 % at 3 years
Touijer [19]	MSKCC	2006	308	TP	–	–	–	–	11.6 %	–	–

(Sx – surgical, EBL – estimated blood loss, BT – blood transfusion, PLND – pelvic lymph node dissection, PSM – positive surgical margin, TP – transperitoneal, EP – extraperitoneal, MSKCC – Memorial Sloan Kettering Cancer Center, MGH – Massachusetts General Hospital)

comes were published in 2002 spurring the growth of "robotic prostatectomy revolution" [21]. – We present a review of the current state of RALP.

■ Robotic-Assisted Laparoscopic Radical Prostatectomy

Although radical retropubic prostatectomy is the gold standard for the treatment of clinically localized prostate cancer, RALP has yielded comparable and promising outcomes in medium-term follow-up series including: operative time, blood loss, LOS, postoperative pain, continence, potency and oncological results.

■ Operative Time (OR)

Mean operative time for reported robotic series ranges from 141–540 minutes and decreases significantly with increasing surgeon experience [22–26]. In our initial experience of 200 cases, OR significantly decreased from an average of 202 minutes (1–50) to 141 minutes for the last fifty cases [27]. Analysis of our current data of 1500 consecutive cases shows that OR times have been further reduced to less than 90 minutes [28]. This is also confirmed by Ahlering et al who reported similar experience-related reduction with a mean of 184 minutes for their last 10 cases compared to an overall of 207 minutes [29].

■ Estimated Blood Loss (EBL) and Transfusion Rate

Traditionally RRP has been associated with higher EBL and transfusion rates. In a comparative study, Menon et al reported a significantly higher rate of transfusion after RRP (67 %) compared to RALP (0 %) [30]. Although diminished blood loss has been the hallmark of laparoscopic prostatectomy, other RALP series have reported mean EBL ranging from 75–900 ml with most being less than 200 mL [22]. Several studies have demonstrated that pneumoperitoneum exerts a tamponade effect that aids in diminishing blood loss from venous sinuses. Large RALP series like the Vattikuti Institute's and Ohio State University's [28] report transfusion rates ranging from 0–0.4 %, respectively [26].

■ Length of Hospital Stay (LOS)

Length of hospital stay is an important component of convalescence after surgery and is often considered a measure of patient well-being. A shorter LOS indicates subjectively a lower degree of morbidity and a faster recovery varying and depending upon the type of surgery, clinical pathway, surgeon practice patterns and cultural differences. The usual LOS after RRP varies between 1–3 days [31]. In a single surgeon comparative study, Ahlering et al reported shorter LOS in patients after RALP compared to RRP (25.9 hrs vs. 52.8 hrs) [23]. Similar findings were reported by Tewari et al with a mean LOS of 1.2 days for the RALP group versus 3.5 days for the RRP group [32]. Our current data of 1500 consecutive cases demonstrates a mean LOS of 1.1 days with 97 % of the patients being discharged on postoperative day one [28].

■ Postoperative Pain

As with most minimally invasive procedures, RALP is performed through several small incisions and is associated with minimal postoperative pain. In the few published studies, there are conflicting reports on reduction in postoperative pain with RALP. Menon et al reported that there was a statistically significant difference in visual analog pain score on postoperative day number 1 with RALP having a mean score of 3 (1–7) compared to RRP with a mean score of 7 (4–10) [26]. In a

study by Webster et al, the converse was reported with no statistical difference in pain on day of surgery using the Likert pain scale with RALP having a mean score of 2.52 compared to 2.88 in the RRP group [33].

■ Continence

Our initial series of 200 patients was evaluated 2 years ago and we reported continence rates of 47 %, 82 %, 89 %, 92 % and 98 % at 1, 3, 6, 9 and 12 months, respectively. It was demonstrated that 27 % of patients were continent immediately after catheter removal. Continence was defined as "no pads" and the data was collected by an independent third party [27].

Menon et al reported a 95.2 % continence rate at 12 months following lateral prostatic fascia-sparing RALP in 2652 patients. They also noted that thirty-three percent of patients had a > 3-point improvement in the IPSS. Continence was defined as "no pads or a single pad for security purposes only and failure to leak urine on provocative manoeuvres". At the time of catheter removal 25 % of patients were pad free [26].

Ahlering et al reported on their first 45 RALP cases and subsequently on case numbers 46–105. Sixty-three percent and eighty-one percent of patients in their first 45 cases were pad free at 1 and 3 months, respectively. An additional 25 % and 14 % used a security pad at 1 and 3 months and in the following 60 cases, 76 % were pad free at 3 months [23]. Questionnaires were either patient reported or administered by a non-clinical research associate. In their first 72 RALP cases, Carlsson et al reported that 90 % of patients were pad free at 3–6 months postoperatively. Information was gathered by self-administered patient questionnaires [34].

Analysis of our current series after 1500 cases at the Ohio State University shows a continence rate of 27 %, 92 %, 97 % and 97.8 % immediately after catheter removal, 3, 6 and 12 months, respectively [35]. We have recently modified our technique, incorporating a suspension stitch from the dorsal vein complex to the pubic symphisis, gaining an earlier return to continence in these patients.

■ Potency

Theoretically, *de novo* erectile dysfunction after radical prostatectomy occurs by injury of the neurovascular bundles (NVB): thermal or traction, direct incision or incorporation of the NVBs into hemostatic sutures and/or clips. Several studies have demonstrated that younger age, preoperative potency, comorbidities and nerve sparing technique are key factors affecting the recovery of erectile function [36].

Menon et al at the Vattikuti Institute in Detroit, recently described and reported potency results for their technique of lateral prostatic fascia-sparing (Veil of Aphrodite) RALP [37]. These men were evaluated with a self-administered SHIM questionnaire preoperatively and at 12 months postoperatively. Recovery of normal erections was defined as a SHIM score > 21. Intercourse was defined by an answer of > 2 (sometimes or more often) on question 2 ("when you had erections from sexual stimulation, how often were your erections hard enough for penetration?"). Using these criteria, 70 % and 100 % of men with a preoperative SHIM score > 21 reported normal erections and intercourse at 12 and 48 months, respectively. Fifty percent of them attained normal SHIM score without medication.

Chien et al reported early sexual outcomes using a clipless nerve sparing RALP technique. Sexual outcomes were evaluated with the use of a self-reported validated questionnaire pre-operatively and at 1, 3, 6, and 12 months postoperatively. While 80 patients underwent RALP during this study period, 35 patients were excluded from final analysis due to either follow-up < 3 months, open conversion or incomplete questionnaires. It was found at 1 month postoperatively that patient's sexual function scores had returned to 47 % of their preoperative scores. This increased to 54 %, 66 %, and 69 % at 3, 6, and 12 months postoperatively. Also reported was a subjective sexual potency, defined as "the ability to penetrate and complete intercourse with or without the use of oral PDE-5 inhibitors". Using this definition, 50 % (10 men) of patients undergoing bilateral nerve sparing RALP were potent and 44 % (8 men) of patients undergoing unilateral bilateral nerve sparing RALP were potent (at 6 months follow-up) [38].

After a 9-month follow-up of their first 45 RALPs, Ahlering et al reported that 1 out of 3 patients who were preoperatively potent had satisfactory postoperative sexual function with sildenafil [39]. Using a cautery-free neurovascular bundle dissection, they also reported early potency outcomes. A comparison was made between patients undergoing unilateral or bilateral nerve preservation (23/45) and 36 "controls" (standard bipolar cautery dissection). Erectile function was assessed through self-administered questionnaires and defined as erections sufficient for vaginal penetration with or without PDE-5 inhibitors. After 3 months of follow-up, 43 % of men in the cautery-free group were potent compared with 8.3 % of the control group. While longer follow-up for the cautery-free group is awaited, the authors commented that at 16 months follow-up 60 % of the control group were potent [40].

At the Ohio State University, our approach to the prostatectomy is antegrade in the standard manner. However, we have modified our nerve sparing technique in order to provide the least trauma to the neurovascular bundle. Our approach to the nerve sparing is athermal with early retrograde release of the NVB, inter-fascial or intra-fascial depending upon tumor burden and location. Between March 2006 and December 2006, 332 patients with localized prostate cancer underwent nerve sparing RALP by the modified technique [35]. Bilateral nerve sparing procedure was performed in 201 (60.5 %) patients, unilateral nerve sparing in 60 (18.2 %) and non-nerve sparing technique was used in 71 (21.3 %) patients. Out of these patients, 167 patients with pre-operative SHIM score > 17, who underwent unilateral or bilateral nerve sparing procedure and had at least 3 months of postoperative follow-up, were included in the review. Out of 167 patients, 134 (80 %) patients were potent with or without use of PDE-5 inhibitors. Fifteen (9 %) patients were potent immediately after catheter removal, 46 (27.5 %) were potent at 1 month follow-up, 115 (68.8 %) were potent at 3 months follow-up, 133 (79.6 %) were potent at 6 months follow-up and 134 (80 %) were potent after 12 months of follow-up.

In their first 100 RALPs, Mikhail et al reported obtaining 68 % and 79 % of potency in patients who underwent unilateral or bilateral nerve preservation, respectively, after a 12-month follow-up, excluding those with preoperative impotence, sural nerve grafting or those with non-sparing procedures [41].

■ Oncologic Outcomes

The reported positive margin rates (PMR) after RALP series range from 0–36 %. When stratified by stage, PMRs following RALP range from 0–17 % for T2a, 0–33 % for T2b, 0–82 % for T3a, 20–50 % for T3b, and 33–67 % for T4 [42]. Although no statistical significance was demonstrated, Ahlering et al reported a trend toward a higher rate of PMRs in the RRP group (20 %) compared to the RALP group (16.7 %).

In our first series of 200 patients the PMR for T2, T3a, T3b, and T4 tumors was 5.7 %, 29 %, 20 % and 33 %, respectively [27]. As our technique refines and current 1500 consecutive cases we have seen a reduction in our PMRs: 4 % for pT2, 34 % for T3 and 40 % for pathologic stage T4. The distribution of positive surgical margins was: apex (23 %), bladder neck (14.5 %), posterolateral (36.7 %) and multifocal (26 %). When analyzing the rate of positive margins based on final pathologic prostate volume, we found that in patients with prostate volumes of less than 50 g, 50–99 g and greater than or equal to 100 g, positive margin rates were 14.3 %, 9.4 %, and 5.9 %, respectively.

For RALP to be accepted as a satisfactory alternative to the current gold standard, oncologic outcomes must be proven to be uncompromised.

■ Discussion

Retropubic radical prostatectomy is currently the gold standard treatment for localized prostate cancer and it has withstood the test of time in terms of oncological and functional outcomes for patients with prostate cancer [1].

Throughout the years technology has made an effort to improve surgical techniques and approaches to guarantee patients better perioperative outcomes and quality of life. The introduction of LRP in the 1990s marked the beginning of a new era: minimally invasive surgery, which demonstrated perioperative outcomes (postoperative pain, return of continence and recovery of potency) comparable to RRP. However, mainstream urology failed to embrace it because of its steep learning curve and prolonged OR times. In short, traditional open surgeons were introduced with new instruments, 2D vision and the lack of normal dexterity of conventional surgery (non-wristed instruments and counterintuitive manoeuvres).

With an enhanced 3D vision and wristed instruments, RALP laid the foundations for a minimally invasive approach combined with traditional open surgery techniques in 2001 [20]. In other words, it allowed urologists to perform radical prostatectomy with enhanced 3D vision using traditional open surgery movements.

Our series of 1500 cases demonstrates a potency rate of 80 % at 12 months follow-up in patients with a preoperative SHIM score > 17. We believe this is due to our current approach to nerve sparing: athermal, antegrade with early retrograde release of the NVBs, minimizing traction and thermal injury and precise application of clips onto the pedicles after delineating the path of NVBs. We demonstrated a continence rate of 97.8 % after 12 months follow-up. Some of the key technical steps helping in achieving excellent continence include: suspension of the urethra to the pubic bone by placing a suspension stitch, apical dissection to achieve maximum urethral length and performing a continuous mucosa to mucosa watertight anastomosis by the technique described by van Velthoven.

■ Conclusion

Our review of the literature suggests that minimally invasive robotic-assisted laparoscopic radical prostatectomy is associated with shorter OR time, decreased blood loss and transfusion rate, shorter LOS, less pain and promising continence, potency and oncological outcomes when compared to contemporary RRP and LRP series. Although robotics is still in its infancy and there are no long-term follow-up studies, many international series have demonstrated that there appears to be an earlier return of continence and recovery of potency in patients undergoing this type of surgery. More information will be available as series continue to mature. With continued refinement of the operative technique we will see further improvement in outcomes.

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Vipul R. Patel, M. D.

Dr. Patel is the director of the Global Robotics Institute at Celebration Health in Orlando, Florida. He leads one of the world's most experienced robotic surgery teams and travels worldwide to educate physicians and care for patients. He is Editor in Chief of The Journal of Robotic Surgery and Editor of the first ever Robotic Urology textbook. Dr. Patel is world renowned for his contribution to the field of robotic surgery and is committed to personalized patient care and quality outcomes. He is one of the most experienced robotic surgeons in the world and has personally performed almost 2000 robotic prostatectomies.

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