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Review – Laparoscopy

Evidence from Robot-Assisted Laparoscopic Radical Prostatectomy: A Systematic Review

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Abstract

Objective: To review the literature available on robot-assisted laparoscopic radical prostatectomy (RALP).
Methods: A literature search was performed using EMBASE, MEDLINE, and Web Science databases through a ''free text'' protocol, including the following terms: robotic radical prostatectomy, da Vinci, and radical prostatectomy. Three of the authors separately reviewed the records to select the papers relevant for the topic of the review, with any discrepancies solved by open discussion. The selected articles were recorded in an electronic database and analysed by version 13.0 SPSS software.
Results: We identified 71 manuscripts. Eleven papers focused on surgical technique, and 35 manuscripts reported clinical, pathologic, and/or follow-up data. Seven studies included clinical data concerning surgical series with fewer than 10 patients, whereas the remaining 26 series reported larger surgical series of RALP. RALP turned out to be a feasible procedure, with limited blood loss, favourable complication rates, and short hospital stays. Positive surgical margin rates decreased with the surgeon's experience and technique improving, reaching percentages similar to those of retropubic and laparoscopic series. The available oncologic data are only preliminary. Especially interesting are the data on postoperative continence rates, whereas results on potency, although promising, are based only on a limited number of patients and have to be considered as incomplete and premature.
Conclusion: Literature showed that RALP had a short learning curve and interesting postoperative results, especially with regard to continence recovery. The available data on recovery of erectile function and oncologic follow-up are still incomplete.

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1. Introduction

Although first performed in 1992 [1], laparoscopic radical prostatectomy (LRP) received little attention until the first reports from France. In Europe, the first LRP was performed by Richard Gaston in September 1997. In the following years, Guillonneau and Vallancien standardised the Montsouris technique and facilitated the spread of LRP to several European centres [2–7].

The shift from open to laparoscopic surgery represents a completely new experience for the surgeon, who must learn a new surgical anatomy and new operative procedures and must deal with new surgical tools. More specifically, the reduction of the range of motion (only 4 df), two-dimensional vision (two-dimensional camera and display), the impaired eye–hand coordination (misorientation between real and visible movements), and the reduced haptic sense (only minimal tactile feedback) are the main restrictions associated with a steep learning curve [7]. For surgeons with no experience with laparoscopy, the learning period could amount to as many as 80–100 consecutive cases, extending over several years [8].

Robotic systems have recently been introduced in an attempt to reduce the difficulty in performing complex laparoscopic urologic procedures, particularly for nonlaparoscopic surgeons [9]. The first system, with a surgeon's console and remotely controlled telemanipulators, was developed with funding from the US Department of Defense in 1991 and came to be called the Stanford Research Institute (SRI) Green Telepresence Surgery System after Phil Green, PhD, a researcher at SRI [10,11]. That early system had only 4 df, similar to standard laparoscopic instruments. In 1995, Fredrick Moll licensed the commercial rights to the SRI Green Telepresence Surgery System and used this acquisition to found Intuitive Surgical Systems. After further development, a renovated master–slave clinical system was released in April 1997 in prototype form as the da Vinci surgical system, which received US Food and Drug Administration (FDA) approval in July 2000. The da Vinci robot includes a true three-dimensional imaging system that provides magnification up to $\times$12. This system also incorporates the patented Endowrist technology, which duplicates the dexterity of the surgeon's forearm and wrist at the operative site, thus providing 7 df.

The first robotic-assisted radical prostatectomy was performed in May 2000 by Binder et al., a skilled open surgeon without laparoscopic experience who worked in Frankfurt [12]. In the same year, other European surgeons skilled in LRP began performing this new technique [13–15]. The first robot-assisted prostatectomy in the United States was performed in November 2000 at the Vattikuti Institute of Urology (Detroit, MI) by Vallencien during a mentorship program [16]. Subsequently, the Vattikuti Institute prostatectomy (VIP) team described an original technique and performed $>$1000 robot-assisted radical prostatectomies until 2004 [17,18].

Robotic-assisted laparoscopic prostatectomy (RALP) is now in widespread and rapidly expanding use. A great deal of data are now available that allow us to draw some initial conclusions about the reproducibility, safety, and efficacy of RALP in terms of functional and oncologic results. For this reason, we decided to perform a systematic review of this very interesting oncologic field.

2. Materials and methods

A literature search was performed in February 2006, using EMBASE, MEDLINE, and Web Science databases. The search protocol included multiple ''free text'' queries, using the following terms across all the fields of the records: robotic radical prostatectomy, da Vinci, and radical prostatectomy. Subsequently, the searches were pooled and the following limits were used: humans, gender (male), language (English). Three of the authors separately reviewed the records to select the papers relevant for the topic of the review, with any discrepancies solved by open discussion. Studies published only as abstracts and reports from meetings were not included in the review, nor were papers published in journals not available in our country. In addition, other significant studies cited in the reference lists of the selected papers were considered. The selected articles were divided into ''review articles'' and ''research papers.''

All the papers were distinguished according to the grade of evidence as stated by Phillips and Sackett [19]. Meta-analyses of randomised clinical trials (RCTs) constitute the highest evidence (level 1a), followed by an adequately sampled single randomised clinical trial (level 1b) and observational studies (level 2). A lower grade of evidence was provided by case-control studies (level 3) and surgical series (level 4). The corresponding grades of recommendation were A for level 1 studies, B for level 2 or 3 studies, and C for level 4 studies [19].

All the data retrieved from the selected studies were recorded in an electronic database and analyzed by version 13.0 SPSS software.

3. Results

3.1. *Systematic search and rating of the evidence*

We identified 81 records in MEDLINE, 77 in Web Science, and 54 in EMBASE. After pooling the three searches, we collected 83 records. Sixteen articles

(18%) were excluded because they were either not relevant to the topic of the review or published in journals impossible to find (*Current Urology Reports*, *International Journal of Medical Robotics and Computer Assisted Surgery*, *Korean Journal of Urology*, *Minimally Invasive Therapy and Allied Technologies*). Analysing the reference lists of the 67 remaining studies, we found 4 more relevant articles, which were included in the analysis. Among the 71 manuscripts, 23 were ''reviews'' and 48 were ''research papers.'' Specifically, in this latter group, 2 papers focused on cost analyses [20,21], 11 on issues of surgical technique [17,22–30], and 35 on clinical, pathologic, and/or follow-up data. For the purposes of our review, the results of 33 clinical trials, published from August 2000 to March 2006, were recorded in an electronic database. Seven studies included clinical data concerning surgical series with fewer than 10 patients [12–15,31–33], and the remaining 26 reported on larger surgical series of RALP performed from May 2000 to 2005.

Five studies compared the results of RALP and open retropubic radical prostatectomy (RRP) in a nonrandomised way [34–38]; three studies compared the results of RALP to contemporary series of laparoscopic radical prostatectomy (LRP) [16,39,40].

Most of the studies were rated as level 4 of evidence, being case series or poor-quality case-control studies, with the exception of a few comparative studies [35–38,40], which were considered as level 3b of evidence [19].

The analysed studies were performed in eight centres in the United States (Alabama; Boston, MA; Chicago, IL; Cleveland, OH; Detroit, MI; Irvine, CA; Nashville, TN; Rochester, NY), four from Europe (Creteil, Frankfurt, Heilbronn, Paris), one from Australia (Melbourne), and one from Asia (Singapore).

3.2. *Surgical techniques*

The fist robotic surgical procedures performed in Frankfurt by surgeons without specific laparoscopic experience followed a mixed antegrade and retrograde route, similar to the techniques for retropubic radical prostatectomy described by Walsh and Campbell [41]. On the other hand, European surgeons, expert in laparoscopy, reproduced robotically the antegrade Montsouris [3] or the retrograde Heilbronn [5] techniques.

In the United States, the first 22 cases were performed at the Vattikuti Institute of Urology by Menon, Guillennau, and Vallancien following the Montsouris technique. In the subsequent 18 cases, Menon et al. developed an original approach, which has become the most commonly used technique for robotic radical prostatectomy, the Vattikuti Institute prostatectomy (VIP) [16,42].

The most important modifications in that antegrade, transperitoneal approach were proposed by Ahlering et al., who reported an original technique for prostate apex dissection and control of the Santorini venous complex by the use of a vascular stapler [43].

In subsequent years, attention was focused on the improvement of nerve-sparing techniques. In 2005, Kaul et al. reported a modified nerve-sparing VIP, which included preservation of the prostatic fascia. When performed correctly this technique allowed surgeons to reach an intact veil of tissue, which hangs from the pubourethral ligament. Kaul et al. called this dissected prostatic fascia the ''veil of Aphrodite'' [30]. In the opinion of the Vattikuti team, this technique was linked to better preservation of neural tissue with apparent improvement in potency rates. In the same year, Ahlering's group described a technique of cautery-free neurovascular preservation for RALP, by use of laparoscopic bulldog clamps and FloSeal to control vascular pedicles and guarantee appropriate hemostasis along the posterolateral plane of dissection [27]. Another interesting nerve-sparing technique, which did not use clips and monopolar coagulo-electrocautery, was reported by Chien et al. [44].

All the techniques described above were transperitoneal and antegrade. Other authors developed extraperitoneal antegrade techniques for RALP [31,45]. Extraperitoneal exposure allows separation of the surgical field from the intraperitoneal contents and may help confine any postoperative urine or lymphatic leak. On the other hand, the working space is more confined and there may be clashing of the instruments. This issue should reflect the preference and the experience of surgeons. To date, no comparative studies between transperitoneal and extraperitoneal RALP have been published.

3.3. *Learning curve and initial experiences*

Table 1 summarises the most important data from the first reports published in the literature, with series including fewer than 10 patients. The studies reported the initial experience with RALP, which was shown to be technically feasible, through both the transperineal [12–15,33] and extraperitoneal [31] routes. In addition, Kaouk et al. showed that the da Vinci remote robotic system technically facilitated sural nerve grafting during LRP [32].

Other significant data concerning the learning curve were derived from the series including the

Table 1 – Main clinical and pathologic features with initial experiences reporting fewer than 10 patients

Author	Year	No. of cases	Notes	Operative time (min)	Blood loss (ml)	Complication rate	In-hospital stay (d)	Catheter removal (d)	Positive surgical margin rate	
									pT2 tumours	pT3 tumours
Binder [12]	2001	10	Initial series	540	nr	10%[a]	≤3	18	0%	75%
Abbou [13]	2001	1	First case at Creteil	420	nr	0	4	3	nr	0%
Pasticier [14]	2001	5	First cases at Montsouris	222	800	20%	5,8	6,5	20%	nr
Rassweiler [15]	2001	6	First cases at Heilbron	315	nr	0%	nr	7,3	0%	0%
Gettman [31]	2003	4	First cases with extra-peritoneal route	274	1013	0%	5,3	2,7	33%	0%
Kaouk [32]	2003	3	First cases of nerve-grafting	375	216	0%	2,3	17	nr	67%
Perer [33]	2003	1	First case at Irvine	390	300	0%	1	7	nr	100%

Level of evidence was 4 for all the studies.
nr = not reported.
[a] Conversion rate.

first 40–60 patients treated by RALP in the most important urologic centers [8,16,34,44,48] (Table 2).

The operative time necessary to complete RALP is significantly reduced as the surgeon's experience grows. In the initial series of Menon et al., after 18 procedures operative times for RALP became progressively shorter than those for LRP performed by experienced surgeons [16]. Analysing their learning curve, Bentas et al. reported that there was a 22-min decrease in the time required to perform the radical prostatectomy and lymphadenectomy for each case [46]. Similarly, Ahlering et al. in their initial cases reported that the learning curve to 4-h proficiency was 12 patients, whereas operative time decreased to an average of 184 min in cases 36–45 [8]. Bladder-neck transection, seminal vesical mobilisation, and urethral anastomosis were the surgical steps where major time reductions were observed along the learning curve [8].

In the RALP series included in the learning curve, mean blood loss ranged from 145 to 570 ml, with lower ranges around 25–100 ml and higher ranges around 350–2500 ml. A percentage of patients ranging from 0% to 32% received a blood transfusion. The highest conversion rate was 5%, reported by the Frankfurt group in their initial series [46]. Perioperative complication rates ranged from 1% to 42%.

The comparative studies available showed that operative times for the first 40 RALPs performed at the Vattikuti Institute during their structured training program were similar to those of LRP performed by two expert French laparoscopists (Guillonneau and Vallancien) in the same period. Furthermore, a significant reduction of blood loss was recorded in patients treated by the da Vinci system. No differences were detected with regard to the other clinical and pathologic features [16]. The comparison between the first 30 RALPs performed by Menon and 30 retropubic radical prostatectomies carried out by one of the surgeons of the Vattikuti Institute team demonstrated that RALP required significantly longer operating times but guaranteed lower rates of blood loss, blood transfusion, and postoperative pain as well as earlier patient discharge. The study showed no significant differences in catheterisation time and positive surgical margin rates [34].

3.4. *Postoperative outcomes in "mature" clinical series*

Studies by Menon et al. showed that once the learning curve was completed, mean operating times can be as low as 180 min, with ranges between 81 and 365 min [49]. Similar results were reported in cases of both transperitoneal [40,50,51] and extraperitoneal

Table 2 – Initial experiences reporting >10 cases reported

Author	Year	No. of cases	Operative time (min)	Blood loss (ml)	Transfusion rate (%)	Conversion rate (%)	Complication rates (%)	Major complications (no. reported)	In-hospital stay (d)	Catheter removal (d)
Menon [16]	2002	40	274	256	0%	0%	5%	Port hernia (1), ureter entrapment (1), pelvic haematoma (1)	1	nr
Menon [34]	2002	30	288	329	7%	3%	20%	Port hernia (1), retention (1)	1.5	10.7
Bentas [46]	2003	41	498	570	32%	5%	41.7%	Injury epigastric artery (1), injury of obturator nerve (1), PE (2), DVT (1), anastomotic leak (4)	17	16.7
Ahlering [8]	2003	45	225	145	0%	0%	8.8%	Anastomotic leak (2), anastomosis disruption (1), leg pain (1)	1.5	7
Sim [47]	2004	17	247	494	18%	0%	6%	Pulmonary atelectasis (1)	2.7	9.8
Chien [44]	2005	56	354	356	2%	0%	9%	nr	1.9	6.6
Patel [48]	2005	50	202	151	0%	0%	1%	Rectal injury (2)	nr	nr

In comparative studies, only the data concerning robot-assisted laparoscopic prostatectomy were reported. Level of evidence was 4 for all the studies.
DVT = deep venous thrombosis; PE = pulmonary embolism; nr = not reported.

[45] route. Particularly interesting were the data reported by Patel et al., who, in a community setting, had results similar to those obtained in academic centres [48]. Blood loss was limited in all the evaluated series, with transfusion rates ranging from 0% to 12%. Overall complication rates ranged from 1.5% to 16%. Duration of hospitalisation was influenced by the health care policy of the different centres. However, it is evident that a high percentage of patients can be discharged within 48 h after surgery. The catheter was removed in the planned postoperative day in >90% of patients.

A comparison of the results of the first 200 RALPs performed by Menon with 100 consecutive contemporary RRPs showed that operative times were similar once the learning curve was completed. Similarly, the study confirmed the advantages of robotic-assisted technique with regard to blood loss, transfusion rates, postoperative pain, and hospitalisation time [35]. Similar data were provided by Ahlering et al., comparing the last 60 RALPs performed from June 2003 to August 2004 with the last 60 RRPs carried out in 2001 and 2002 in the same institution [36]. Contrasting data were published by Webster et al., who reported a nonrandomised study, comparing 159 RALPs and 154 RRPs performed at Vanderbilt University Medical Center (Nashville, TN). The authors did not show any significant advantage in terms of postoperative pain scores between the two groups [37]. In another study, moreover, the same group reported similar transfusion rates in open and robotic groups [38].

Two studies compared RALP and LRP [39,40]. Joseph et al. compared retrospectively the last 50 RALPs to the last 50 LRPs and found no differences in terms of operative times and transfusion and postoperative complication rates [39]. Comparable data were also obtained by Hu et al. [40].

Table 3 summarises postoperative outcome in mature series, beyond the learning curve.

3.5. *Oncologic outcome*

The rates of positive surgical margin were extremely variable, ranging from a minimum of 2% [57] to a maximum as high as 59% [47]. Those percentages, however, are highly influenced by the pathologic stage of the primary tumour. Stratifying the data by pathologic stage, positive surgical margin rates were between 4.7% and 27% in pT2 [43] and between 26% and 67% in pT3 cancers [46,48] (Table 4).

The surgeons' increasing expertise as well as improvements in surgical techniques allowed a progressive reduction in the rates of positive

Table 3 – Postoperative data beyond the learning curve

Author	Year	No. of cases	Operative time (min)	Blood loss (ml)	Transfusion rate (%)	Conversion rate (%)	Complication rates (%)	Major complications (no. reported)	In-hospital stay (d)	Catheter removal (d)
Menon [52]	2003	100	195	149	0%	0%	8%	Port hernia (2), DVT (1), ileus (1)	nr	nr
Menon [53]	2003	200	160	153	0%	0%	8%	Port hernia (3), ileus (3), DVT (1), bleeding (1)	1.2	7
Wolfram [54]	2003	81	250	300	12%	nr	nr	nr	nr	14
Ahlering [36]	2004	60	231	103	0%	0%	6.7%	PE (1), urine leak (1), ileus (1), bleeding (1)	1	7
Chatelineau [50]	2004	105	180	500	6%	2%	8%	Rectal injury (1), sigmoid erosion (1), extraprostatic abscess (1), haematomas (2), urine leak (3)	5.5	7
Costello [55]	2005	122	nr	nr	3%	nr	16%	Urine leak (6), Bladder-neck stenosis (5), rectal injury (1), rectal fistula (1)	nr	nr
Ahlering [56]	2005	81	236	105	0%	0%	4.9%	Ileus (1), urine leaks (2), PE (1)	1.2	nr
Patel [48]	2005	200	141	75	0%	0%	1.5%	nr	1.1	7.9
Bhandari [49]	2005	300	177	109	0%	0%	5.7%	Bowel injury (2), DVT (1), ileus (5)	1.2	6.9
Joseph [39]	2005	50	202	206	0%	0%	8%	Bladder-neck stenosis (3), urine leak (1)	nr	nr
Hu [40]	2006	322	186	250	1.6%	0.6%	17.2%	Ureteral injury (1), urine leaks (24), bladder- neck stenosis (2), ileus (9), bleeding (2), DVT (2)	nr	nr
Van Appledorn [51]	2006	150	191	nr	2.6%	0%	3.3%	Rectal injury (1), bleeding (4)	3.4	nr
Farnham [38]	2006	176	nr	191	0.5%	0%	nr	nr	nr	nr
Joseph [45]	2006	325	130	196	1%	0%	9.6%	Urine leakage (4), rectal injury (1), bladder-neck stenosis (7), DVT (4), AMI (3), PE (1)	1	nr

Level of evidence was 4 for all the studies, with the exception of 3b for Ahlering [36], Franham [38], and Hu [40].
DVT = deep venous thrombosis; PE = pulmonary embolism; AMI = acute myocardial infarction; nr = not reported.

Table 4 – Positive surgical margin rates reported in robot-assisted laparoscopic prostatectomy series

Author	Year	No. of cases	Pathologic stage			Overall PSM rate (%)	PSM rate (%)		
			pT2	pT3a	pT3b		pT2	pT3a	pT3b
Menon[a] [52]	2003	100	85%	5%	9%	15%	10.5%	40%	40%
Menon [53]	2003	200	86.8%	6.8%	6.3%	6%	nr	nr	nr
Wolfram [54]	2003	81	68.5%	31.5%		22%	12.7%	42%	
Bentas [46]	2003	41	63%	22%	15%	30%	8%	67%	
Ahlering[b] [43]	2004	50	62%	36%		36%	27%	50%	
Ahlering[b] [43]	2004	90	73%	27%		16.7%	4.7%	44%	
Chatelineau [50]	2004	105	71%	29%		22%	11.7%	43%	
Sim [47]	2004	17	53%	47%		59%	nr	nr	nr
Costello [55]	2005	122	80%	16%	4%	16%	nr	nr	nr
Patel [48]	2005	200	78%	14%	8%	10.5%	5.7%	26.2%	33%
Joseph [39]	2005	50	88%	12%		12%	nr	nr	nr
Menon [57]	2005	35	98%	2%		2%	nr	nr	nr
Chien [44]	2005	56	82%	18%		11%	nr	nr	nr
Joseph [45]	2006	325	81%	14%	5%	13%	9.9%	37.1%	27.3%
Van Appledorn [51]	2006	150	nr	nr	nr	17.3%	nr	nr	nr

Level of evidence was 4 for all the studies.
PSM = positive surgical margin; nr = not reported.
[a] The surgical margins were marked with India ink, and the prostatectomy specimen was fixed en bloc with formaldehyde and then sectioned transversally at 5-mm intervals. The transverse apical section consisted of a shave about 1–2 mm thick and 10 mm in diameter, which was sectioned longitudinally to permit accurate assessment of the apical margin.
[b] All specimens were inked and sectioned according to a standard protocol. The apex was shaved perpendicular to the axis of the urethra and sliced radially, generating five to eight segments. The base was also shaved and submitted entirely in two to four cassettes. The remainder of the prostate and attached seminal vesicle were serially sectioned in the transversal plane at 3–5-mm intervals.

surgical margin. In Menon's experience, the rate of positive margin declined from 15% in the first 100 cases [52] to 4% in the last 100 [42]. The studies coming from a community setting also showed a fall in the percentage of positive margin from 13% in the first 100 cases to 8% in the subsequent 100 [48]. Similarly, Ahlering et al. observed significant reductions in the positive surgical margin in pT2 cases, from percentages as high as 27% in the first 50 cases to 4.7% in the subsequent 90 patients, treated with a modified technique for prostate apex dissection [43].

With regard to nerve-sparing techniques, in the cautery-free neurovascular preservation technique Ahlering et al. reported rates of positive surgical margin (21.7%) similar to those of the standard technique with bipolar electrocautery (16.7%) [27]. Even the nerve-sparing technique with preservation of prostatic fascia proposed by Menon (veil of Aphrodite) did not cause a significant improvement in positive surgical margin rates, compared to the traditional nerve-sparing technique [57].

The two prospective, nonrandomised comparative studies available showed that the positive surgical margin rates were higher in patients who had undergone RRP compared to RALP [35,36]. By contrast, Joseph et al. reported similar percentages of positive surgical margins, comparing the last 50 cases of RALP to the last 50 cases of LRP [39].

In most of the papers concerning surgical margin status, however, prostatectomy specimen sampling was not described. Only papers from the Vattikuti Institute and Irvine gave accurate descriptions. In the former centre, prostates were serially sectioned in the transverse plane at 5-mm intervals, whereas a 3–5-mm interval was used in the latter. Both groups underscored the role of a special sampling for prostate apex [43,53].

Data on biochemical disease-free survival (bDFS) were available from 11 studies. All the evaluations were performed at mean follow-up <6 mo, and the percentages of patients with prostate-specific antigen (PSA) values lower than 0.1–0.2 ng/ml ranged between 82% [43] and 100% [39].

3.6. *Functional outcomes*

The limited follow-up available do not provide long-term functional data, such as urinary continence and erectile function recovery. Urinary continence recovery, defined as use of no protection system or use of a single liner for security reasons, was as high as 72–95% at a 3-mo follow-up. Similarly to RRP and LRP, continence rates increased throughout the follow-up (Table 5). Studies presenting data at follow-up longer than 12 mo showed continence rates between 84% and 98% [46,48]. Ahlering et al. demonstrated that continence recovery was impaired by body mass index (BMI). Patients with a BMI >30 had a 6-mo continence rate of 47% compared to 91% observed in patients with a BMI <30 [56].

Table 5 – Continence recovery after robot-assisted laparoscopic prostatectomy

Author	Year	No. of cases	Continence definition	Method of data collection	Continence rates (%)		
					3-mo	6-mo	12-mo
Menon [52]	2003	100	0-1 pad (“safety pad”)	Interview	72.5%	91.6%	nr
Menon [53]	2003	200	0-1 pad (“safety pad”)	Interview	nr	96%	nr
Bentas [46]	2003	41	0-1 pad (“safety pad”)	Questionnaire	nr	nr	84%
Ahlering [8]	2003	45	0-1 pad (“safety pad”)	Questionnaire	95%	nr	nr
Ahlering [43]	2004	50	No pad	Questionnaire	73%	nr	nr
Ahlering [43]	2004	90	No pad	Questionnaire	81%	nr	nr
Sim [47]	2004	17	No pad	Interview	82%	nr	nr
Costello [55]	2005	122	0-1 pad (“safety pad”)	Questionnaire	73%	82%	nr
Patel [48]	2005	200	No pad	Questionnaire	82%	89%	98%
Joseph [45]	2006	325	No pad	Questionnaire	93%	96%	nr

Level of evidence was 4 for all the studies; nr = not reported.

The only published nonrandomised study comparing continence rates after RALP and RRP showed that robotic surgery allowed earlier continence recovery compared to the traditional retropubic approach [35].

Few data are currently available on erectile function after nerve-sparing RALP. Progressive improvements in potency rates were observed along the follow-up. The available 12-mo follow-up data suggested that percentages of patients ranging between 20% and 97% can have sexual intercourse after nerve-sparing RALP [46,57]. Patients’ age and surgical techniques can influence these functional results. Menon et al. showed significantly higher 3- and 6-mo potency rates in patients younger than 60 yr, compared to older patients operated on with the same surgical technique [53]. With regard to the surgical technique, Ahlering et al. demonstrated in a prospective, nonrandomised, comparative study that the adoption of a cautery-free technique for preservation of neurovascular bundles allowed significantly higher potency rates, even at the 3-mo follow-up, compared to the standard technique [58]. In addition, prostatic fascia preservation at lateral surface of the prostate (veil of Aphrodite) seemed to allow higher potency rates than traditional nerve-sparing RALP [57]. According to the nonrandomised, comparative study of Tewari et al., RALP could allow better and earlier potency recovery, compared to RRP [35] (Table 6).

4. Discussion

RALP is a modern technique for the treatment of clinically localised prostate cancer, which has become widely used in the last 5 yr. Since the first series of 10 patients reported by Binder et al. in 2001, >5000 RALPs have been performed worldwide [59]. Moreover, radical prostatectomy is the most commonly robotically assisted surgical procedure performed in the United States.

Table 6 – Potency recovery after nerve-sparing robot-assisted laparoscopic prostatectomy

Author	Year	No. of cases	Technique	Potency definition	Data collection	Potency rates (%)		
						3-mo	6-mo	12-mo
Menon [52]	2003	100	VIP	Sexual intercourse	IIEF-5		59%	
Menon [53]	2003	200	VIP	Sexual intercourse	IIEF-5	25% (<60 yr) 10% (>60 yr)	64% (<60 yr) 38% (>60 yr)	
Bentas [46]	2003	41	Montsouris	Sexual intercourse	Questionnaire			20%
Ahlering [58]	2005	36	Modified VIP	Sexual intercourse	IIEF-5	11%		
		23	CFT			47%		
Menon [57]	2005	23	VIP	Sexual intercourse	IIEF-5			74%
		35	Veil of Aphrodite					97%
Chien [44]	2005	56	VIP	Return to baseline	UCLA-PCI	54%	66%	69%
Joseph [45]	2006	325	EX technique	IIEF > 21	IIEF-5	46%		

Level of evidence was 4 for all the studies.
VIP = Vattikuti Institute prostatectomy; CFT = cautery-free technique; EX = extraperitoneal; IIEF = International Index of Erectile Function; UCLA-PCI = University of California – Los Angeles Prostate Cancer Index.

High-resolution three-dimensional vision and the possibility of manipulating specialised laparoscopic instruments with 7 df allowed inexperienced or minimally experienced laparoscopic surgeons to shorten the learning curve significantly. Although an examination of the studies available did not allow us to define the precise number of RALPs to be performed to complete the learning curve, 20 procedures seems a reasonable limit to perform such surgery with acceptable operative times and complication rates [8,16,34,46]. However, a skillful laparoscopic assistant for the first surgeon working at the console is needed to achieve these results. Indeed, the exact number of RALPs to be completed before obtaining the functional and oncologic outcomes of RRP or LRP as performed by experienced surgeons is surely larger, with a few authors hypothesising as many as 250 RALPs necessary to complete the learning curve [60]. However, the learning curve can vary considerably, depending on a number of surgeon-related factors such as previous surgical experience, surgeon-declared perception of expertise, definition of expertise, work load, and so on [60]. Moreover, a clear definition of the learning curve is still lacking.

Most of the published papers were single-centre prospective studies. They showed clearly that RALP is a feasible procedure, with limited blood loss, favourable complication rates, and short hospital times. Catheterisation time mirrored the policies of the centres, being on average 7–8 d. Positive surgical margin rates decreased along with the increase in surgeons' experience and technique improvement, reaching percentages similar to those of recent retropubic and laparoscopic series. In several studies, however, the rate of positive surgical margins was not correlated with the method of evaluation of the prostatectomy specimen. Such data should always be reported to allow for easier comparison of the rates of positive surgical margins in different series.

The oncologic data available are to be considered only preliminary, being based only on PSA values at follow-ups of no longer than 6 mo. In addition, the data on postoperative continence rates are very interesting, whereas results on potency are based only on a limited number of patients and have to be viewed as not fully mature. The lack of standardised protocols for postsurgical erectogenic pharmacotherapy, however, can be seen as a further confounding factor [61].

Analysing critically the comparative studies available, it was clear that RALP seems to offer results similar to those of retropubic and laparoscopic radical prostatectomy. The advantages in terms of reduced blood loss, transfusion rates, and postoperative pain scores highlighted in the first comparative study [35] were not reconfirmed in the most recent papers by Webster et al. [37] and Farnham et al. [38]. On the other hand, the lower rates of positive surgical margin in RALP compared to RRP, which was demonstrated by Tewari et al. in 2003 [35], has been subsequently reconfirmed by Ahlering et al. [36]. With regard to continence and potency recovery, the prospective comparative study from Tewari et al. showed significant advantages for RALP compared to RRP [35]. In our opinion, the lack of randomisation procedures and the limited number of patients included in those studies do not permit definitive conclusions, in comparison with larger bodies of evidence available for RRP [62–64].

The main disadvantages of RALP are the costs for robot purchase and maintenance, as well as for operative equipment per case, which overshadowed savings gained by shorter hospital stays [20]. More recently, Scales et al. pointed out that the inpatient costs of RALP were volume-dependent and cost equivalence with generalist RRP was possible at high-volume centres [21]. The consequence is that, currently, not all hospitals may be capable of offering the state-of-the-art technology necessary for RALP because of the equipment expense [65]. However, if in Europe the distribution of the da Vinci system is still restricted to a few academic institutions or private hospitals, in the United States robotic centres are increasing in number, offering ample professional opportunities for robotic specialists.

5. Conclusions

RALP has had a wide diffusion in the last 5 yr, especially in the United States. Costs are the major drawbacks. The literature data showed that RALP has a short learning curve, interesting postoperative results, and promising functional outcome, especially with regard to continence recovery. Comparative multicentre trials, preferably randomised, might allow a more appropriate comparison with the gold standard, represented by RRP. To date, we believe that the use of this technology should be restricted to high-volume, referral centres, within evaluation studies aimed at precise assessment of the clinical results.

References

[1] Schuessler WW, Kavoussi LR, Clayman RV, Vancaillie TG. Laparoscopic radical prostatectomy: initial case report. J Urol 1992;147:A246.

[2] Guillonneau B, Cathelineau X, Barret E, Rozet F, Vallancien G. Laparoscopic radical prostatectomy: technical and early oncological assessment of 40 operations. Eur Urol 1999;36:14–20.
[3] Guillonneau B, Vallancien G. Laparoscopic radical prostatectomy: the Montsouris technique. J Urol 2000;163: 1643–9.
[4] Jacob F, Salomon L, Hoznek A, et al. Laparoscopic radical prostatectomy: preliminary results. Eur Urol 2000;37: 615–20.
[5] Rassweiler J, Sentker L, Seemann O, Hatzinger M, Stock C, Frede T. Heilbronn laparoscopic radical prostatectomy. Technique and results after 100 cases. Eur Urol 2001; 40:54–64.
[6] Turk I, Deger S, Winkelmann B, Schonberger B, Loening SA. Laparoscopic radical prostatectomy. Technical aspects and experience with 125 cases. Eur Urol 2001; 40:46–52.
[7] Rassweiler J, Hruza M, Teber D, Su LM. Laparoscopic and robotic assisted radical prostatectomy—critical analysis of the results. Eur Urol 2006;49:612–24.
[8] 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: 1738–41.
[9] Hemal AK, Menon M. Laparoscopy, robot, telesurgery and urology: future perspective. J Postgrad Med 2002;48:39–41.
[10] Gree PE, Piantanida TA, Hill JW, Simon IB, Satava RM. Telepresence: dexterous procedures in a virtual operating field. Am Surg 1991;57:192, (abstract).
[11] Nguyen MM, Das S. The evolution of robotic urologic surgery. Urol Clin N Am 2004;31:653–8.
[12] Binder J, Kramer W. Robotically-assisted laparoscopic radical prostatectomy. BJU Int 2001;87:408–10.
[13] Abbou CC, Hoznek A, Salomon L, et al. Laparoscopic radical prostatectomy with a remote controlled robot. J Urol 2001;165:1964–6.
[14] Pasticier G, Rietbergen JB, Guillonneau B, Fromont G, Menon M, Vallancien G. Robotically assisted laparoscopic radical prostatectomy: feasibility study in men. Eur Urol 2001;40:70–4.
[15] Rassweiler J, Frede T, Seemann O, Stock C, Sentker L. Telesurgical laparoscopic radical prostatectomy. Initial experience. Eur Urol 2001;40:75–83.
[16] Menon M, Shrivastava A, Tewari A, et al. Laparoscopic and robot assisted radical prostatectomy: establishment of a structured program and preliminary analysis of outcomes. J Urol 2002;168:945–9.
[17] Tewari A, Peabody J, Sarle R, et al. Technique of da Vinci robot-assisted anatomic radical prostatectomy. Urology 2002;60:569–72.
[18] Menon M, Tewari A, Peabody JO, et al. Vattikuti Institute prostatectomy, a technique of robotic radical prostatectomy for management of localized carcinoma of the prostate: experience of over 1100 cases. Urol Clin North Am 2004;31:701–17.
[19] Phillips B, Ball C, Sackett D, et al. Levels of evidence and grades of recommendation. Oxford Centre for Evidence-based Medicine. Downloaded at http://www.cebm.net/levels_of_evidence.asp#levels. Accessed April 2006.
[20] Lotan Y, Cadeddu JA, Gettman MT. The new economics of radical prostatectomy: cost comparison of open, laparoscopic and robot assisted techniques. J Urol 2004;172: 1431–5.
[21] Scales Jr CD, Jones PJ, Eisenstein EL, Preminger GM, Albala DM. Local cost structures and the economics of robot assisted radical prostatectomy. J Urol 2005;174:2323–9.
[22] Tewari A, Menon M. Vattikuti Institute prostatectomy: surgical technique and current results. Curr Urol Rep 2003;4:119–23.
[23] Lee DI, Eichel L, Skarecky DW, Ahlering TE. Robotic laparoscopic radical prostatectomy with a single assistant. Urology 2004;63:1172–5.
[24] Menon M, Hemal AK, Tewari A, Shrivastava A, Bhandari A. The technique of apical dissection of the prostate and urethrovesical anastomosis in robotic radical prostatectomy. BJU Int 2004;93:715–9.
[25] Menon M, Hemal AK, VIP Team. Vattikuti Institute prostatectomy: a technique of robotic radical prostatectomy: experience in more than 1000 cases. J Endourol 2004; 18:611–9.
[26] Pick DL, Lee DI, Skarecky DW, Ahlering TE. Anatomic guide for port placement for daVinci robotic radical prostatectomy. J Endourol 2004;18:572–5.
[27] Ahlering TE, Eichel L, Chou D, Skarecky DW. Feasibility study for robotic radical prostatectomy cautery-free neurovascular bundle preservation. Urology 2005;65:994–7.
[28] Hemal AK, Bhandari A, Tewari A, Menon M. The window sign: an aid in laparoscopic and robotic radical prostatectomy. Int Urol Nephrol 2005;37:73–7.
[29] Esposito MP, Ilbeigi P, Ahmed M, Lanteri V. Use of fourth arm in da Vinci robot-assisted extraperitoneal laparoscopic prostatectomy: novel technique. Urology 2005; 66:649–52.
[30] Kaul S, Bhandari A, Hemal A, Savera A, Shrivastava A, Menon M. Robotic radical prostatectomy with preservation of the prostatic fascia: a feasibility study. Urology 2005;66:1261–5.
[31] Gettman MT, Hoznek A, Salomon L, et al. Laparoscopic radical prostatectomy: description of the extraperitoneal approach using the da Vinci robotic system. J Urol 2003; 170:416–9.
[32] Kaouk JH, Desai MM, Abreu SC, Papay F, Gill IS. Robotic assisted laparoscopic sural nerve grafting during radical prostatectomy: initial experience. J Urol 2003;170:909–12.
[33] Perer E, Lee DI, Ahlering T, Clayman RV. Robotic revelation: laparoscopic radical prostatectomy by a nonlaparoscopic surgeon. J Am Coll Surg 2003;197:693–6.
[34] Menon M, Tewari A, Baize B, Guillonneau B, Vallancien G. Prospective comparison of radical retropubic prostatectomy and robot-assisted anatomic prostatectomy: the Vattikuti Urology Institute experience. Urology 2002; 60:864–8.
[35] Tewari A, Srivasatava A, Menon M, Members of the VIP Team. A prospective comparison of radical retropubic and robot-assisted prostatectomy: experience in one institution. BJU Int 2003;92:205–10.

[36] Ahlering TE, Woo D, Eichel L, Lee DI, Edwards R, Skarecky DW. Robot-assisted versus open radical prostatectomy: a comparison of one surgeon's outcomes. Urology 2004; 63:819–22.
[37] Webster TM, Herrell SD, Chang SS, et al. Robotic assisted laparoscopic radical prostatectomy versus retropubic radical prostatectomy: a prospective assessment of postoperative pain. J Urol 2005;174:912–4.
[38] Farnham SB, Webster TM, Herrell SD, Smith Jr JA. Intraoperative blood loss and transfusion requirements for robotic-assisted radical prostatectomy versus radical retropubic prostatectomy. Urology 2006;67:360–3.
[39] Joseph JV, Vicente I, Madeb R, Erturk E, Patel HR. Robot-assisted vs pure laparoscopic radical prostatectomy: are there any differences? BJU Int 2005;96:39–42.
[40] Hu JC, Nelson RA, Wilson TG, et al. Perioperative complications of laparoscopic and robotic assisted laparoscopic radical prostatectomy. J Urol 2006;175:541–6.
[41] Walsh PC, Donker PJ. Impotence following radical prostatectomy: insight into etiology and prevention. J Urol 1982;128:492–7.
[42] Menon M, Tewari A, Peabody J, The VIP Team. Vattikuti Institute prostatectomy: technique. J Urol 2003;169:2289–92.
[43] Ahlering TE, Eichel L, Edwards RA, Lee DI, Skarecky DW. Robotic radical prostatectomy: a technique to reduce pT2 positive margins. Urology 2004;64:1224–8.
[44] Chien GW, Mikhail AA, Orvieto MA, et al. Modified clipless antegrade nerve preservation in robotic-assisted laparoscopic radical prostatectomy with validated sexual function evaluation. Urology 2005;66:419–23.
[45] Joseph JV, Rosenbaum R, Madeb R, Erturk E, Patel HR. Robotic extraperitoneal radical prostatectomy: an alternative approach. J Urol 2006;175:945–50.
[46] Bentas W, Wolfram M, Jones J, Brautigam R, Kramer W, Binder J. Robotic technology and the translation of open radical prostatectomy to laparoscopy: the early Frankfurt experience with robotic radical prostatectomy and one year follow-up. Eur Urol 2003;44:175–81.
[47] Sim HG, Yip SK, Lau WK, Tan JK, Cheng CW. Early experience with robot-assisted laparoscopic radical prostatectomy. Asian J Surg 2004;27:321–5.
[48] 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;174:269–72.
[49] Bhandari A, McIntire L, Kaul SA, Hemal AK, Peabody JO, Menon M. Perioperative complications of robotic radical prostatectomy after the learning curve. J Urol 2005; 174:915–8.
[50] Cathelineau X, Cahill D, Widmer H, Rozet F, Baumert H, Vallancien G. Transperitoneal or extraperitoneal approach for laparoscopic radical prostatectomy: a false debate over a real challenge. J Urol 2004;171:714–6.
[51] Van Appledorn S, Bouchier-Hayes D, Agarwal D, Costello AJ. Robotic laparoscopic radical prostatectomy: setup and procedural techniques after 150 cases. Urology 2006; 67:364–7.
[52] Menon M, Shrivastava A, Sarle R, Hemal A, Tewari A. Vattikuti Institute prostatectomy: a single-team experience of 100 cases. J Endourol 2003;17:785–90.
[53] Menon M, Tewari A, Vattikuti Institute Prostatectomy Team. Robotic radical prostatectomy and the Vattikuti Urology Institute technique: an interim analysis of results and technical points. Urology 2003;61:15–20.
[54] Wolfram M, Brautigam R, Engl T, et al. Robotic-assisted laparoscopic radical prostatectomy: the Frankfurt technique. World J Urol 2003;21:128–32.
[55] Costello AJ, Haxhimolla H, Crowe H, Peters JS. Installation of telerobotic surgery and initial experience with telerobotic radical prostatectomy. BJU Int 2005;96:34–8.
[56] Ahlering TE, Eichel L, Edwards R, Skarecky DW. Impact of obesity on clinical outcomes in robotic prostatectomy. Urology 2005;65:740–4.
[57] Menon M, Kaul S, Bhandari A, Shrivastava A, Tewari A, Hemal A. Potency following robotic radical prostatectomy: a questionnaire based analysis of outcomes after conventional nerve sparing and prostatic fascia sparing techniques. J Urol 2005;174:2291–6.
[58] Ahlering TE, Eichel L, Skarecky D. Rapid communication: early potency outcomes with cautery-free neurovascular bundle preservation with robotic laparoscopic radical prostatectomy. J Endourol 2005;19:715–8.
[59] Binder J, Brautigam R, Jonas D, Bentas W. Robotic surgery in urology: fact or fantasy? BJU Int 2004;94:1183–7.
[60] Herrell SD, Smith Jr JA. Robotic-assisted laparoscopic prostatectomy: what is the learning curve? Urology 2005;66:105–7.
[61] Mulhall J, Land S, Parker M, Waters WB, Flanigan RC. The use of an erectogenic pharmacotherapy regimen following radical prostatectomy improves recovery of spontaneous erectile function. J Sex Med 2005;2:532–40.
[62] Montorsi F, Salonia A, Suardi N, et al. Improving the preservation of the urethral sphincter and neurovascular bundles during open radical retropubic prostatectomy. Eur Urol 2005;48:938–45.
[63] Graefen M, Walz J, Huland H. Open retropubic nerve-sparing radical prostatectomy. Eur Urol 2006;49:38–48.
[64] Janetschek G, Montorsi F. Open versus laparoscopic radical prostatectomy. Eur Urol Suppl 2006;5:377–84.
[65] Smith Jr JA, Herrell SD. Robotic-assisted laparoscopic prostatectomy: do minimally invasive approaches offer significant advantages? J Clin Oncol 2005;23:8170–5.

Editorial Comment

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In this comprehensive review, which should help the urologists to evaluate the surgical results of RALP, the authors emphasize the need of further evaluation studies aimed at precise assessment of the clinical results.

Given the fact that this robotic system is available to only very few European laparoscopic urologic surgeons—70 systems are installed in academic centers and private groups—use of robotic surgery by high-volume referral centres should be associated with an important effort of evaluation at least by the academic centers.

This evaluation concerns at first the validation of oncologic and functional outcomes as well as complication rates for routine techniques of RALP by comparative multicentre trials, preferably randomised, with the gold standard, represented by RRP as stated by the authors.

But also new technique development allowed by the robotic system performances should be performed by these centers, such as extended lymphatic dissection or extrafascial radical prostatectomy in case of locally avanced cancers. Such procedures were not enough developed or described by laparoscopic surgeons whereas they are still part of our surgical indications. The reason may be that the main interest is in cavernous nerve preservation for most laparoscopic urologists, but it may also be due to the limitation of standard laparoscopic 2D vision and instrumentation with only 4 df, making an enlarged dissection a too difficult challenge.

New technique development with the use in the near future of any peroperative image guidance surgery will give to the robot system a more convincing place to most of us.