Review

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Retropubic, Laparoscopic, and Robot-Assisted Radical Prostatectomy: Surgical, Oncological, and Functional Outcomes: A Systematic Review

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Key Words
Laparoscopy · Prostate cancer · Prostatic adenocarcinoma · Radical prostatectomy · Radical retropubic prostatectomy · Sexual function · Surgery · Urinary incontinence

Abstract
Objectives: Despite the wide diffusion of minimally invasive approaches, such as laparoscopic (LRP) and robot-assisted radical prostatectomy (RALP), few studies compare the results of these techniques with the retropubic radical prostatectomy (RRP) approach. The aim of this study is to compare the surgical, functional, and oncological outcomes and cost-effectiveness of RRP, LRP, and RALP. ***Methods:*** A systematic review of the literature was performed in the PubMed and Embase databases in December 2013. A 'free-text' protocol using the term 'radical prostatectomy' was applied. A total of 16,085 records were found. The authors reviewed the records to identify comparative studies to include in the review. ***Results:*** 44 comparative studies were identified. With regard to the perioperative outcome, LRP and RALP were more time-consuming than RRP, but blood loss, transfusion rates, catheterisation time, hospitalisation duration, and complication rates were the most optimal in the laparoscopic approaches. With regard to the functional and oncological results, RALP was found to have the best outcomes. ***Conclusion:*** Our study confirmed the well-known perioperative advantage of minimally invasive techniques; however, available data were not sufficient to prove the superiority of any surgical approach in terms of functional and oncologic outcomes. On the contrary, cost comparison clearly supports RRP.

Introduction

Prostate cancer is the most common tumour in people aged over 50 years and the second leading cause of cancer death in Northern Europe and the United States. The increase in life expectancy, combined with the use of PSA as a screening method and the reduction of a threshold for prostate biopsy indication, has contributed to an increase in the diagnosis of prostate cancer [1]. Consequently, this has led to an increase in the number of patients who are candidates for radical prostatectomies. Radical prostatectomy (RP) is a common treatment for patients with clinically localised prostate cancer (cT1–cT2) and a life expectancy >10 years. Open RP has long represented the most widely adopted treatment to eradicate prostate cancer. However, the progressive development of minimally invasive surgery and the continuous

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research into surgical techniques that can ensure better outcomes and fewer complications compared with the standard 'open' surgery have led several providers to apply laparoscopic techniques to RP.

In 1997, Schuessler et al. [2] performed the first laparoscopic RP to transfer the well-known advantages of the laparoscopic technique to the most common open surgical treatment for prostate cancer. Subsequently, in 1999, Guillonneau and Vallancien [3] improved the technique and obtained results similar to those of open surgery. Despite the demonstrated efficacy of laparoscopic surgery, the technique has never completely supplanted the 'open' approach. This is mainly due to the long learning curve resulting from the two-dimensional view of the field, the reduced 'range' of motion associated with the lack of tactile feedback, and the need to coordinate hand movements with screen vision, representing a difficult task for any surgeon, even the most experienced in 'open' surgery [4, 5].

The advent of robotic surgery is a further evolutionary step in the development of minimally invasive prostate surgery. The possibility of having a three-dimensional view of the surgical field, with a greater and more intuitive movement capability of the robotic arms, significantly reduces the learning curve [6, 7]. On the other hand, these advantages are offset by the high cost of the 'Da Vinci®' robot, which is available at few institutions [8]. Despite the considerable diffusion of laparoscopic and robotic surgery and the remarkable diversification of the surgical approach used to date, only a few studies have compared these innovative techniques with the classic 'open' approach.

The purpose of this study is to evaluate the peri- and postoperative results, including the oncological and functional outcomes, complications and cost comparison among the 'open', laparoscopic and robotic techniques.

Methods

A literature search was performed in December 2013 using the PubMed and Embase databases. The PubMed and Embase search included only a 'free-text' protocol using the term 'radical prostatectomy' across the 'Title' and 'Abstract' fields of the records. Subsequently, the only language limit used was the selection of English as the default. With these parameters, we found 12,877 records on the PubMed database; 3,208 records were retrieved from the Embase database. Two authors separately reviewed the records to select the studies comparing retropubic radical prostatectomy (RRP) to laparoscopic radical prostatectomy (LRP), RRP to robot-assisted radical prostatectomy (RALP), or LRP to RALP.

We analysed all of the papers published since 1999 to date (1999–2013), only considering the comparative articles. Studies published only as abstracts and reports from meetings were not included in this review. We also reviewed the reference lists of articles and included those articles not already identified by the database search. The endpoints evaluated included perioperative outcomes (operative time, blood loss, transfusion rate, hospital stay, catheter time, and overall complication rates), functional outcomes (urinary continence, potency recovery), and positive surgical margin (PSM) rates and cost-effectiveness. Weighted means were calculated for all outcomes using the number of patients included in each study as the weighting factor.

Statistical Methods

The performance profiles of three surgical operations were characterised by a vector of several variables. Each vector reports aspects used in this dataset for meta-analysis. To achieve a quantitative comparison of the surgical profiles, each variable value was weighted according to the sample size of the study included. A table of adjusted average components of the profile vectors is provided. The comparison addressed the issue of lack of homoscedasticity by performing a weighted OLS regression assuming that the errors have an error distribution of $\varepsilon_i \sim N(0; \sigma^2/w_i)$, where w_i represents the known weights, and σ^2 is an unknown parameter that is estimated in the regression. The comparisons of each vector component across the three surgical treatments were significant with most $p < 0.05$. Because of the independence of the components, after adjusting for multiple tests (Sidak), we found performance profile vectors that were significantly different at $p < 0.05$.

The statistical analysis was conducted using the software STATA version 13. The global results with standard errors and p values are reported in table 1.

Results

We identified 44 relevant articles in the literature search. Among the 44 evaluated papers, 19 compared RRP with LRP, 19 compared RRP with RALP, 4 compared LRP with RALP, and 2 compared all surgical techniques together. The mean patient age (range) for the RRP, LRP, and RARP series included in the studies was 61.3 (58–65), 62.9 (57.6–64), and 60.4 (59.2–63.5) years, respectively.

Perioperative Outcomes and Postoperative Morbidity

The results for operative time, blood loss, blood transfusion rates, catheterisation time, hospital stay, and overall complication rates for RRP, LRP, and RALP are presented in table 2 [10, 14–16, 18–25, 29, 30, 32–37, 39–43, 45, 48, 49, 52–55].

The weighted mean operative times (range) were 179.03 (105–253) min for the RRP series, 236.54 (144–

Table 1. Perioperative outcomes and postoperative morbidity

Study (first author)	Cases (n) and type	Median/mean operative time, min	Median/mean blood loss, ml	Transfusion rate, %	Catheterisation time, days	In-hospital stay, days	Overall complication rate, %
Guazzoni [10]	60 RRP	170	853	9			35
Anastasiadis [18]	70 RRP	179		9	7.8		13
Bhayani [19]	24 RRP	168	1,473		19	3	20.8
Roumeguere [20]	77 RRP	168	1,514		14		29.7
Remzi [14]	41 RRP	195	385		10		24
Jurczok [15]	240 RRP	120	550	9	10.2	11.2	7.9
Touijer [16]	818 RRP	188	1,267	49		3.3	6.6
Artibani [21]	50 RRP	105		0	8.4	10	20
Egawa [22]	49 RRP	230	1,325		14		
Atallah [23]	115 RRP	161			10.8		
Brown [24]	60 RRP		1,355	52		3	18
Poulakis [25]	70 RRP	150	486	24	22	11	53
Salomon [29]	145 RRP	197		26	16		24.8
Rassweiler [30]	219 RRP	196	1,550	55	12	16	18
Martorana [32]	50 RRP	159			15	6.9	
Drouin [49]	83 RRP	208	821	9.6	14.7	7	12
Menon [33]	30 RRP	138	970	17	14		6
Tewari [34]	100 RRP	163	910	67	15.8	3.5	15
Farnham [35]	103 RRP		664	2.9			
Nelson [36]	374 RRP					1.23	15
Fracalanza [37]	26 RRP	127	500	34		8	27
Krambeck [39]	564 RRP	204		13.1			8
Ahlering [40]	60 RRP	214	418	2	9	2	10
Di Pierro [45]	75 RRP	253		3			37
Froehner [48]	2,437 RRP			10.4		7.7	29.1
Rocco [52]	240 RRP	160	800		7	6	
Kordan [53]	414 RRP		450	14			
Son [54]	112 RRP	139	578				
Ryu [55]	341 RRP	170			7.5	10.1	68
Guazzoni [10]	60 LRP	235	257	0			16.6
Anastasiadis [18]	230 LRP	271		2.6	5.8		9.6
Bhayani [19]	33 LRP	348	533		14	2.97	21.2
Roumeguere [20]	85 LRP	288	522		6		14.2
Remzi [14]	39 tLRP	279	290		7		18
Remzi [14]	41 eLRP	217	189		7		7.3
Jurczok [15]	163 LRP	180	200	3	8.9	9.4	8.1
Touijer [16]	612 LRP	199	315	3		2	2.9
Artibani [21]	71 LRP	180		11	7	7	37
Egawa [22]	34 LRP	400	860		6.5		
Atallah [23]	50 LRP	201			7.9		
Brown [24]	60 LRP	348	317	1.7		2.8	25
Poulakis [25]	72 LRP	144	205	3	7	9	23
Salomon [29]	137 LRP	285		3	7		18.2
Rassweiler [30]	219 LRP	288	1,100	30	7	12	12
Rassweiler [30]	219 LRP	218	800	9.6	7	11	6.3
Martorana [32]	50 LRP	358			13	5	
Drouin [49]	85 LRP	257	558	5.9	8.9	6.1	7
Menon [5]	40 LRP	258	391	2.5		1	
Hu [41]	358 LRP	246	200	2.2			33
Rozet [42]	133 LRP	160	512	9.8	9	4.9	9.1
Joseph [43]	50 LRP	235	299	0			
Menon [33]	30 RALP	288	329	7	11	1.5	6
Tewari [34]	200 RALP	160	153	0	7	1.2	3

Table 1. (continued)

Study (first author)	Cases (n) and type	Median/mean operative time, min	Median/mean blood loss, ml	Transfusion rate, %	Catheterisation time, days	In-hospital stay, days	Overall complication rate, %
Farnham [35]	176 RALP		191	0.5			
Nelson [36]	629 RALP					1.17	17
Fracalanza [37]	35 RALP	195	300	17		5	9
Krambeck [39]	286 RALP	236		5.1			4.8
Ahlering [40]	60 RALP	231	103	0	7	1	6.7
Di Pierro [45]	75 RALP	330		0			40
Froehner [48]	317 RALP			8.9		8	33
Drouin [49]	71 RALP	199	310		8.1	4.4	8.4
Rocco [52]	120 RALP	215	200		6	3	
Kordan [53]	830 RALP		100	7			
Son [54]	146 RALP	137	144				
Ryu [55]	524 RALP	146			6.2	7.9	27.3
Menon [5]	40 RALP	276	254	0			
Hu [41]	322 RALP	186	250	1.6			16
Rozet [42]	133 RALP	166	609	3	9.2	5.4	19.4
Joseph [43]	50 RALP	202	206	0			

tLRP = Transperitoneal LRP; eLRP = extraperitoneal LRP.

400) min for the LRP series, and 187.91 (137–330) min for the RALP series. The weighted mean estimated blood loss (EBL) for RRP, LRP, and RARP was 935, 442, and 191 ml, respectively. The weighted mean intra- and postoperative transfusion rates for RRP, LRP and RARP were 19.93, 6.3, and 4.66%, respectively. In terms of the length of hospital stays, the RRP series had a weighted mean of 7.87 days; the weighted mean hospital stay for LRP and RARP was 6.09 and 3.85 days, respectively. The weighted mean catheterisation time (range) for RRP, LRP, and RARP was 12.85 (1.23–16), 10.32 (1–12), and 6.96 (1–8) days, respectively. The weighted mean for the rate of postoperative complication rates (range) for RRP, LRP, and RARP were 23.2% (6–68%), 13.42% (2.9–37%), and 18.52% (3–40%), respectively.

Functional Outcomes

Urinary Continence

The postoperative urinary continence outcomes for RARP, LRP, and RRP are shown in table 3 [14, 16, 18, 20–22, 25, 30, 39, 43, 45, 50, 52, 54].

The evaluation of urinary continence rates between different studies is difficult. This is due mainly to the lack of standard data collection methods (the use of non-validated questionnaires or simple interviews) and the use of different definitions. Furthermore, follow-up is often insufficient or only partial.

In our study, we identified continence as the use of no absorbent pads or no leakage at all. We identified 14 studies with reported and comparable urinary continence rates (uncompleted outcomes at 6, 12, and 24 months). Evaluating RRP, the weighted mean continence rates were 73.71 and 83.22% at 6 and 12 months of follow-up, respectively. Only 2 studies evaluated incontinence at 24 months of follow-up (both found 82% continence rates). The LRP-weighted mean continence rates were 63.8 and 70.7% at 6 and 12 months of follow-up, respectively; only one study evaluated incontinence at 24 months of follow-up and reported a continence rate of 62%. Finally, RARP patients had continence rates, at 6 and 12 months of follow-up, of 89.12 and 92.78%, respectively. Only one study evaluated incontinence at 24 months of follow-up in the RALP series, and it reported a continence rate of 95.2%.

Erectile Function

The postoperative erectile function outcomes for RRP, LRP, and RARP are shown in table 3 [14, 16, 18, 20–22, 25, 30, 39, 43, 45, 50, 52, 54].

Among the 44 comparative studies analysed, only 8 provide accurate erectile function data, and only 2 papers used a validated questionnaire, such as the International Index of Erectile Function (IIEF) [9]; all other studies used non-validated questionnaires or open interviews. The RRP-weighted mean potency rates at 3, 12, and 24

Table 2. Functional outcomes (continence and potency)

Study (first author)	Cases (n) and type	Method	Criterion	6 months, %	12 months, %	24 months, %
Continence						
Anastasiadis [18]	70 RRP	NVQ	no pad	43.3	77.7	
Roumeguere [20]	56 RRP	interview	no pad		83.9	
Remzi [14]	41 RRP	physician	no pad		80.3	
Touijer [16]	222 RRP	NVQ	no pad		75	82
Artibani [21]	14 RRP	interview	no pad		78.5	
Egawa [22]	41 RRP	interview	no pad	84.1	92.9	
Poulakis [25]	70 RRP	ICS male short form	no pad	70		
Rassweiler [30]	219 RRP	physician	no pad		89.9	
Krambeck [39]	564 RRP	NVQ	no leak		93.7	
Di Pierro [45]	75 RRP	NVQ	no leak		80	
Geraerts [50]	116 RRP	physician	no leak	85.3	83.8	
Rocco [52]	240 RRP	interview	no pad/one safety pad	83	88	
Son [54]	112 RRP	NVQ	no pad	51.7	70.7	82.1
Anastasiadis [18]	230 LRP	NVQ	no pad	59.2	89	
Roumeguere [20]	52 LRP	interview	no pad		80.7	
Remzi [14]	39 tLRP	physician	no pad		84.6	
Remzi [14]	41 eLRP	physician	no pad		87.8	
Touijer [16]	193 LRP	NVQ	no pad		48	62
Artibani [21]	20 LRP	interview	no pad		60	
Egawa [22]	34 LRP	interview	no pad	46.9	60	
Poulakis [25]	72 LRP	ICS	no pad	67		
Rassweiler [30]	219 LRP	physician	no pad		90	
Rassweiler [30]	219 LRP	physician	no pad		91.7	
Joseph [43]	50 LRP	physician	no pad	92		
Krambeck [39]	286 RALP	NVQ	no leak		91.8	
Di Pierro [45]	75 RALP	NVQ	no leak		89	
Geraerts [50]	64 RALP	physician	no leak	90.3	89.8	
Rocco [52]	120 RALP	interview	no pad/one safety pad	93	97	
Son [54]	146 RALP	NVQ	no pad	87.5	94.5	95.2
Joseph [43]	50 RALP	physician	no pad	90		
				3 months, %	12 months, %	24 months, %
Potency						
Anastasiadis [18]	70 RRP	NVQ	ES for intercourse		72	
Roumeguere [20]	33 RRP	IIEF	ES for intercourse	33.3		
Touijer [16]	222 RRP	NVQ	ES for intercourse			58.5
Krambeck [39]	564 RRP	NVQ	intercourse		62.8	
Di Pierro [45]	75 RRP	NVQ	presence of erection	25	68	
Rocco [52]	240 RRP	interview	intercourse	18	31	41
Anastasiadis [18]	230 LRP	NVQ	ES for intercourse		81	
Roumeguere [20]	26 LRP	IIEF	ES for intercourse	34.6		
Touijer [16]	193 LRP	NVQ	ES for intercourse			56
Joseph [43]	50 LRP	IIEF	ES for intercourse	36		
Krambeck [39]	286 RALP	NVQ	intercourse		70	
Di Pierro [45]	75 RALP	NVQ	presence of erection	26	55	
Rocco [52]	120 RALP	interview	intercourse	31	43	61
Joseph [43]	50 RALP	IIEF	ES for intercourse	46		

NVQ = Non-validated questionnaire; ES = erection sufficient; tLRP = transperitoneal LRP; eLRP = extraperitoneal LRP.

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Table 3. Oncological outcomes

Study	Cases (n) and type	Overall PSM, %	pT2 PSM, %	pT3 PSM, %
Guazzoni [10]	60 RRP	21.6	18.2	31.24
Anastasiadis [18]	70 RRP	28.6		
Roumeguere [20]	77 RRP	40	7.3	
Remzi [14]	41 RRP	19.5		
Jurczok [15]	240 RRP	19.6	12.6	31
Touijer [16]	818 RRP	11		
Artibani [21]	50 RRP	24	6	37.5
Egawa [22]	49 RRP	28.6		
Brown [24]	60 RRP	20		
Poulakis [25]	70 RRP	23	12	37
Silva [26]	89 RRP	41.5	34.2	77.7
Terakawa [27]	220 RRP	23.6	17.3	34.6
Fromont [28]	139 RRP	25.9	21	41.2
Salomon [29]	145 RRP	31.7	19	52.7
Rassweiler [30]	219 RRP	28.7	17	
Salomon [31]	116 RRP		18.9	
Martorana [32]	50 RRP	26	17.8	
Drouin [49]	83 RRP	18.1	7.3	66.7
Harty [51]	153 RRP	52.9	15	74
Menon [33]	30 RRP	29		
Tewari [34]	100 RRP	23		
Fracalanza [37]	26 RRP	23	18	36.3
Smith [38]	200 RRP	35.7	24	60
Krambeck [39]	564 RRP	17		
Ahlering [40]	60 RRP	20	9	50
Williams [44]	346 RRP	8.6		
Di Pierro [45]	75 RRP	32	24.1	55.5
Laurilla [46]	98 RRP	12.2	15	24
Weizer [47]	515 RRP	16	12	
Geraerts [50]	116 RRP	21		
Rocco [52]	240 RRP	25	16	42
Kordan [53]	414 RRP	31.2		
Vora [56]	95 RRP	58.9		
Guazzoni [10]	60 LRP	26	24.4	33.3
Anastasiadis [18]	230 LRP	26.5		
Roumeguere [20]	85 LRP	26	7.8	
Remzi [14]	39 tLRP	25.6		
Remzi [14]	41 eLRP	19.5		
Jurczok [15]	163 LRP	16.6	9.8	29
Touijer [16]	612 LRP	11		
Artibani [21]	71 LRP	30	14	39
Remzi [14]	41 eLRP	19.5		
Jurczok [15]	163 LRP	16.6	9.8	29
Touijer [16]	612 LRP	11		
Artibani [21]	71 LRP	30	14	39
Egawa [22]	34 LRP	50		
Brown [24]	60 LRP	16.9		
Poulakis [25]	72 LRP	21	12	31
Silva [26]	90 LRP	24.4	20.9	62.5
Terakawa [27]	132 LRP	39.4	30.2	71
Fromont [28]	139 LRP	13.7	10	23.1
Salomon [29]	137 LRP	28.4	22	40.8
Rassweiler [30]	219 LRP (1)	21	12	
Rassweiler [30]	219 LRP (2)	23.7	17	
Salomon [31]	119 LRP		18.9	
Martorana [32]	50 LRP	24	19.3	
Drouin [49]	85 LRP	18.8	17	72.7
Harty [51]	140 LRP	41.4	12	88
Menon [5]	40 LRP	25		
Rozet [42]	133 LRP	15.8	15.5	
Joseph [43]	50 LRP	14		
Menon [33]	30 RALP	26		
Tewari [34]	200 RALP	6		
Fracalanza [37]	35 RALP	28	17	54.5
Smith [38]	200 RALP	15	9.4	50
Krambeck [39]	286 RALP	15.6		
Ahelering [40]	60 RALP	16.7	4.5	50
Williams [44]	524 RALP	15.2		
Di Pierro [45]	75 RALP	16	8.3	42.8
Laurilla [46]	94 RALP	11.7	10	49
Weizer [47]	118 RALP	18	14	
Drouin [49]	71 RALP	15.4	9.8	60
Geraerts [50]	64 RALP	30		
Harty [51]	152 RALP	50	12	79
Rocco [52]	120 RALP	22		34
Kordan [53]	830 RALP	20.6		
Menon [5]	40 RALP	17		
Rozet [42]	133 RALP	19.5	20	
Joseph [43]	50 RALP	12		
Vora [56]	140 RALP	47.1		

tLRP = Transperitoneal LRP; eLRP = extraperitoneal LRP.

months were 22.34, 55.85 and 54.53%, respectively. The LRP-weighted mean potency rate at 3 months of follow-up was 35.12%; potency rates at 12 and 24 months of follow-up were each only reported by one paper (81 and 56%, respectively). Regarding RALP, patients displayed potency rates at 3 and 12 months of follow-up of 32.53 and 60.93%, respectively. Only one article included a 24-month potency follow-up (61% potency rate at 24 months). Unfortunately, the same lack of standardisation seen for urinary continence can be noted in the erectile function analysis. Very often, collected data are incomparable among studies, or the follow-up period is too short.

Oncological Outcomes

The PSM rates for RRP, LRP, and RALP series are summarised in table 4 [10, 14–16, 18, 20–22, 24–34, 36–39, 42–47, 49–53, 56].

Table 4. Statistical analysis (global results expressed as weighted mean)

	Study			p value
	RRP	LRP	RALP	
Operative time, min	179.03	236.54	187.91	0.0000
SE	0.47	0.97	1.02	
Blood loss, ml	935.86	442.32	191.03	0.0000
SE	7.36	5.88	2.65	
Transfusion rate, %	19.93	6.3	4.66	0.0011
SE	0.23	0.16	0.07	
Catheterisation time, days	12.85	10.32	6.96	0.0000
SE	0.22	0.35	0.04	
In-hospital stay, days	7.87	9.02	5.87	0.0000
SE	0.13	0.37	0.23	
Overall complication rate, %	23.2	13.42	18.52	0.0000
SE	0.19	0.21	0.19	
Continence 6 months, %	73.71	63.82	89.12	0.0000
SE	0.52	0.61	0.24	
Continence 12 months, %	83.22	70.77	92.78	0.0015
SE	0.16	0.5	0.1	
Continence 24 months, %	NE	NE	95.2	3.542361111
SE			0.01	
Potency 3 months, %	22.34	35.12	32.53	0.0000
SE	0.31	0.06	0.46	
Potency 12 months, %	55.85	NE	60.93	3.266666667
SE	0.48		0.53	
Potency 24 months, %	54.53	NE	NE	5.521527778
SE	0.23			
Overall PSM, %	22.45	22.04	21.14	0.0000
SE	0.14	0.18	0.24	
pT2 PSM, %	16.64	17.44	10.53	0.314583333
SE	0.11	0.16	0.1	
pT3 PSM, %	46.75	49.61	53.37	0.2433
SE	0.35	0.68	0.5	

SE = Standard error; NE = not evaluable.

RALP revealed a weighted mean overall PSM rate of 21.14%, whereas LRP and RRP yielded PSMs of 22.04 and 22.45%, respectively. Analysing only pT2 stage tumours, we found that RALP, LRP, and RRP had PSM rates of 10.53, 17.44, and 16.64%, respectively, whereas for pT3 stage tumours, we obtained PSM rates of 53.37, 49.61 and 46.75% for RALP, LRP and RRP, respectively. The statistical analysis of all of the comparative studies reporting data on PSM rates suggests that the PSM rates were similar for RRP versus LRP; on the contrary, statistical analysis of all of the comparative studies reporting data on RRP and LRP versus RALP margin status indicates a significant difference in favour of RALP. However, despite the available state-of-the-art techniques, this study found a controversial outcome. No final conclusions can be drawn from these findings, and more studies are needed to fully answer the question of superiority.

Discussion

It is very difficult to compare open RP with the laparoscopic and robotic approaches because the available clinical studies have several limitations. Almost all of the available data derive from prospective, non-randomised, or retrospective studies, which provide a low level of evidence.

Performing a randomised controlled trial is clearly a very difficult task, as many patients cannot be randomised on surgical approach because most of them are unwilling

Urol Int 2014;93:373–383
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to accept the idea of randomisation to a particular surgical treatment and are usually quite fascinated by the most modern surgical procedure or chose a procedure based on personal preferences for a specific surgeon. A patient has no choice of surgical approach only when their medical condition does not permit particular techniques. In this context, in those units that perform several techniques simultaneously, patients with low-risk disease more often underwent RARP, whereas almost all patients with high-risk disease (≥cT3, PSA ≥20 and Gleason score ≥8) underwent open surgery because they required an extended lymph node dissection.

Among the few randomised controlled trials, Guazzoni et al. [10] demonstrated that LRP has advantages over RRP in terms of reduced blood loss and a higher percentage of safe early catheter removal, with comparable oncologic results in terms of positive margins rates. Porpiglia et al. [11] demonstrated in their randomised controlled trial the advantage of RALP on LRP approaches in terms of the recovery of continence and potency.

Centres performing laparoscopic or robotic surgery usually focus mainly on these approaches, abandoning or limiting considerably their practice using traditional open surgery. Consequently, in many papers, historical instead of contemporary controls for RRP are used leading for an unfit comparison with the more recent minimally invasive procedures database. Moreover, though in many studies RRPs were performed by several surgeons with varying levels of expertise, laparoscopic or robotic procedures were usually performed by a small number of dedicated urologists. Furthermore, some of the comparative studies excluded the early learning curve of the mini-invasive RP, introducing further bias. This issue has particular significance if we consider that the LRP approach, more so than the robotic approach, suffers from a long learning curve. Whereas the RALP is more intuitive, the restrictions related to LRP, including the reduction of the range of motion, two-dimensional vision, impaired eye-hand coordination (i.e. misorientation between real and visible movements), and reduced haptic sense, lead to a steep learning curve. Finally, definitions used to describe positive margins, such as urinary continence and sexual functioning, are not standardised and may differ significantly between the series.

Pelvic Lymph Node Dissection

Pelvic lymph node dissection (PLND) is a controversial aspect of RP. Controversies exist regarding both the patients who should undergo PLND and the extent of nodal dissection.

Prediction models have been created to assess the risk of lymph node involvement and help guide practitioners in making more informed decisions [12]. According to the NCCN guidelines, a PLND can be excluded in patients with <2% predicated probability of nodal metastases by nomograms. However, with the increasing prevalence of RALP in urological practice, the feasibility of PLND as well as the adequacy of nodal yield have been investigated. It has been demonstrated that patients undergoing RRP are more likely to have concomitant PLND compared with patients undergoing RALP, based on various factors such as surgical volume, robotic learning curve, operative time, and cost [13].

Lymph node status was not included in this study because this information was often unavailable. Only 4 of 44 of the papers (9%) reported PLND data. Guazzoni et al. [10] limited pelvic lymphadenectomy at patients with total serum PSA level >10 ng/ml and/or Gleason score = 7 (45% of RRP and 40% of LRP). Remzi et al. [14] proceeded to PLND in all laparoscopic patients, staging lymphadenectomy of the obturator fossa and in only 71% of RRP (PSA >10 ng/ml, Gleason score >6) with no nodal involvement reported. Jurczok et al. [15] and Touijer et al. [16] extended PLND to all patients regardless of their risk stratification.

In the future, continued emphasis must be placed on performing PLND during RP by all surgical approaches in all prostate cancer patients with >2% risk of lymph node involvement, as presently recommended by NCCN guidelines.

Perioperative Data

The main perioperative parameters evaluated to compare the retropubic, laparoscopic and robotic approach to RP were operative time, blood loss, transfusion rates, duration of hospital stay, catheterisation time, and overall complication rate. It is difficult to compare operative times among different series because of variations in reporting operative time (the inclusion of setup time and/or PLND).

In our study, the weighted mean operative time was shorter for RRP (179.03 min), whereas the operative times for both LRP and RALP were longer (236 and 187 min, respectively) with little difference between RALP and RRP sessions ($p = 0.000$). Such differences between LRP and RRP are significantly larger during the initial phase of the learning curve, but they decrease with experience. The data in the literature indicate that RALP simplifies the learning process, allowing faster reduction in operative time compared with pure LRP.

Decreased intraoperative blood loss is a reported great advantage of laparoscopic/robot-assisted prostatectomy.

Currently, plexus Santorini is mostly well controlled. Bleeding originates more frequently from dorsolateral vessels maintained during nerve-sparing. Moreover, the tamponade effect created by pneumoperitoneum and the early identification and precise ligation of vessels helps diminish blood loss. Our findings indicate that RALP facilitated a significant reduction in blood loss with consequent lower perioperative transfusion rates compared with RRP (mean EBL 191 vs. 935 ml, respectively, and transfusion rates 4.66 and 19.93%, respectively, p = 0.000). Similarly, transfusion rates were significantly lower in patients undergoing LRP compared with RRP (mean EBL 442 vs. 935 ml, respectively, and transfusion rates 6.3 and 19.93%, respectively, p = 0.000). Alternatively, LRP and RALP performed similarly with regard to blood loss and transfusion rates (mean EBL 442 vs. 191 ml, respectively, and transfusion rates 6.3 and 4.66%, respectively, p = 0.000).

A large variability in the duration of hospitalisation and catheterisation time was observed in the evaluated series, which most likely reflected the differences in the location where the series were carried out. In Europe, patients often stay in the hospital until the urinary catheter is removed, whereas in the United States, the patients are usually discharged quickly after surgery.

The main comparative studies indicate that the robotic approach has significant advantages, mainly in terms of in-hospital stay but also for catheterisation time. The mean in-hospital stay was higher for the RRP and LRP series than in the RALP series in our review (7.87, 6.09, and 3.85 days, respectively, p = 0.000). The mean catheterisation time displayed better results for RALP compared with LRP and RRP (6.96, 10.32, and 12.85 days, respectively, p = 0.000). Our hypothesis regarding the other perioperative parameters is confirmed for the overall complication rates.

Data from comparative studies indicate a significant advantage for the RALP and LRP series in comparison with the RRP series when evaluating complication rates (18.52% vs. 13.42 and 23.2%, respectively, p = 0.000), with LRP having the best results. We can say that once the learning curve is completed, LRP and RALP can be performed without a significant risk of major complications and with better results than RRP.

Functional Outcomes

The evaluation of continence outcomes after RP remains difficult due to the lack of standardisation among series. Only a few of the available comparative studies used validated questionnaires, and the outcomes were often assessed by an open interview. Furthermore, follow-up is often insufficient or only partial. In this situation, only trends can be suggested as to whether any particular approach delivers superior continence outcomes.

In our review, the weighted mean continence rates at 6 months for the RRP, LRP, and RARP series were 73.71, 63.82, and 89.12%, respectively (p = 0.000). After a 12-month follow-up, the continence rates for the RRP, LRP, and RALP series were 83.22, 70.77, and 92.78%, respectively (p = 0.001). Evaluation at 24 months of follow-up was impossible because few papers conducted follow-up using this interval (2 studies for RRP and 1 study for LRP and RALP).

Our data support the statement that the continence rates after RRP and LRP were similar, with RRP performing slightly better than LRP. The RARP continence rates were higher in our study when compared with RRP and LRP. Randomised prospective studies are necessary, however, to accurately compare the continence rates between the three surgical approaches.

Regarding potency rates, the data are too limited for evaluation. In our review, data from the available comparative studies suggested an advantage in terms of urinary continence and erectile function for patients who underwent RALP compared with those patients subjected to the RRP and LRP techniques, but future studies are needed to confirm this trend.

Oncological Outcomes

PSMs are the most used and collected data for oncological RP analysis. This is mainly because of the lack of long-term biochemical recurrence and disease-free survival rate data. In our study, we analysed the overall PSM rates and pT2 PSM rates among comparative studies. We found similar PSM rates for RRP and LRP (22.45 and 22.04%, respectively, p = 0.000), whereas RALP was only slightly better compared with the other techniques (21.14%). These differences become significant if we consider only the pT2 stage with similar rates for the RRP and LRP series (16.64 and 17.44% pT2 PSM rates, respectively, p = 0.045) and lower rates for RALP (10.53% pT2 PSM rates). Randomised trials are necessary, however, before definitive conclusions can be reached.

Cost

The use of robot-assisted laparoscopic prostatectomy introduces another issue. The cost for a single procedure with RALP is much higher for the cost of LRP or RRP. As Bolenz et al. [8] have demonstrated, the median direct cost is higher for RALP compared with LRP or RRP (RALP, USD 6,752; LRP, USD 5,687; RRP, USD 4,437). The main difference is in the cost of surgical supplies (RALP, USD 2,015; LRP, USD 725; RRP, USD 185) and operating room

Urol Int 2014;93:373–383
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costs (RALP, USD 2,798; LRP, USD 2,453; RRP, USD 1,611). When considering the purchase of and maintenance costs for the robot, the financial burden increases by USD 2,698 per patient. Close et al. [17] also found worse economic results (robotic prostatectomy was on average GBP 1,412 more expensive than laparoscopic prostatectomy). These results are similar to those of other comparative studies. The financial standpoint must be considered just as much as the other surgical outcomes in choosing surgical techniques.

Conclusion

The evaluation and comparison of RP techniques is very difficult. We can state that pure LRPs and RALPs have significantly lower blood loss and transfusion rates and have all of the traditional advantages of minimally invasive procedures. However, even if data from this systematic review suggest better results for RALP in terms of functional and oncologic outcomes, to date there is no certain proof of its superiority. Contrasting results among comparative studies associated with the lack of randomised trials and long-term follow-up studies that compare the three approaches precludes definitive conclusions. It is likely that the surgeon's experience, rather than the surgical approach, can best determine the surgical results. For example, an LRP performed by a qualitatively poor surgeon would not be superior to an RRP performed by a skilled surgeon (and vice versa).

To date there is no reason that a surgeon obtaining excellent functional and oncologic results with RRP should switch to a different approach. Alternatively, surgeons obtaining suboptimal results might improve them by shifting to a different approach. On the other hand, cost comparison merits special mention. The exponential growth of medical costs globally, linked with the use of increasingly more expensive technologies, makes it necessary to search for diagnostic and therapeutic tools that ensure the best possible result with the least possible expense to make the best available treatment accessible to the entire population. Currently, the cost for a single RALP procedure is much higher than for LRP or RRP. In this context, the use of robotic technology should be limited to centres dealing with a high volume of prostate cancer. Moreover, growing competition among robotic technology producers is bound to lower the overall cost.

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