Revisão
Review

Curative Surgery for Localized Prostate Cancer - Robot-Assisted *Versus* Laparoscopic Radical Prostatectomy: A Systematic Review of Reviews on Perioperative Efficacy and Safety Outcomes

Cirurgia Curativa para Cancro da Próstata Localizado – Prostatectomia Radical Assistida por Robot Versus Laparoscópica: Uma Revisão Sistemática de Revisões Sobre Resultados de Eficácia e Segurança Perioperatória

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Abstract

Introduction: Several systematic reviews comparing laparoscopic radical prostatectomy (LRP) and robot-assisted radical prostatectomy (RARP) have been published, yielding heterogeneous results. We aimed to summarize this body of evidence.

Methods: A PubMed search was conducted to identify systematic reviews with or without meta-analyses that compared LRP and RARP. Data regarding perioperative parameters, complications, and oncological outcomes were extracted and analyzed.

Results: Intraoperative and postoperative outcomes appear broadly comparable between the two approaches. Most studies demonstrate benefits for RARP in operative time, estimated blood loss, and transfusion rates. Complication rates and positive surgical margin rates tend to be similar. RARP offers a significant advantage over LRP regarding the learning curve for surgeons, albeit at increased cost.

Conclusion: While both techniques yield comparable outcomes, the robotic approach shows modest perioperative benefits.

Study Protocol: PROSPERO database (Registration Number: CRD42025630631).

Keywords: Laparoscopy; Prostatectomy; Prostatic Neoplasms/surgery; Robotic Surgical Procedures

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Resumo

Introdução: Foram publicadas várias revisões sistemáticas que comparam a prostatectomia radical laparoscópica (PRL) com a prostatectomia radical assistida por robot (PRAR), tendo produzido resultados heterogéneos. O nosso objetivo foi sintetizar a evidência.

Métodos: Foi realizada uma pesquisa na PubMed para identificar revisões sistemáticas, com ou sem meta-análises, que comparassem PRL e PRAR. Foram extraídos e analisados dados relativos a parâmetros perioperatórios, complicações e resultados oncológicos.

Resultados: Os resultados intraoperatórios e pós-operatórios parecem, de um modo geral, comparáveis entre as duas abordagens. A maioria dos estudos demonstra vantagens da PRAR no tempo operatório, na perda de sangue estimada e nas taxas de transfusão. As taxas de complicações e de margens cirúrgicas positivas tendem a ser semelhantes. A PRAR parece oferecer uma vantagem significativa relativamente à curva de aprendizagem dos cirurgiões, embora associada a custos superiores.

Conclusão: Embora ambas as técnicas apresentem resultados comparáveis, a abordagem robótica revela benefícios perioperatórios modestos.

Protocolo do Estudo: Base de dados PROSPERO (Número de Registo: CRD42025630631).

Palavras-chave: Laparoscopia; Neoplasias da Prostata/cirurgia; Procedimentos Cirúrgicos Robóticos; Prostatectomia

Introduction

The increase in prostate cancer (PC) screening programs in recent decades has led to a greater number of patients diagnosed in the early stages of PC and many of these patients are candidates for surgical treatment. While adequate cancer treatment is of paramount importance, considerable effort has been devoted to reducing the surgical morbidity. In this regard, the application of minimally invasive techniques has brought the possibility of reducing surgical complications.

Initially, through the advent of laparoscopy, prostate surgery experienced a revolution. Literature data showing improvements in complications, postoperative pain, length of hospital stay and cosmetic outcome, when comparing to the conventional, open, approach.[1,2]

More recently, surgery has broken through a new phase with the emergence of robotic procedures, which currently have one of their main applications in prostatectomies. The robotic surgical system allows the surgeon to command robotic arm movements from telehandlers, enabling precise surgical movements and facilitating the execution of operations by minimally invasive access.[3]

The robotic platform "da Vinci", with its various versions, all produced by Intuitive Surgical, is the most widely available model for clinical use in the world.[4] It was approved by the FDA for commercial use in the United States in the year 2000.[5] Following the approval, an increase in the use of the robotic system to perform radical prostatectomy (RP) was observed, leaping from 13% in 2003 to 72% in 2011[6] to more than 90%, presently.[7] However, this rapid increase in the popularity of RARP preceded the accumulation of high-quality evidence demonstrating its superiority over laparoscopy.

Innovative equipment and treatments are, for various reasons, attractive to physicians and patients, who tend to adhere to new technologies even before their merits and weaknesses are fully established. This process can lead to increased health care costs. In this regard, only in recent years have we observed studies of greater scientific rigor comparing the two approaches of minimally invasive surgery for the treatment of PC. This review aims to compile data from other systematic reviews and meta-analyses available in the literature that make a counterpoint between laparoscopic radical prostatectomy and robotic radical prostatectomy.

Methods

A systematic review of the literature was conducted following the criteria of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[8,9] to answer the following PICO question: in patients with clinically localized PC, does robot-assisted radical prostatectomy, compared to conventional laparoscopic radical prostatectomy, offers better results, such as lower transfusion rate, shorter hospitalization period and lower rate of positive margins in the surgical specimen? The PRISMA checklist was completed and this review is formally registered with PROSPERO, bearing the registration number CRD42025630631.

https://www.crd.york.ac.uk/PROSPERO/view/CRD42025630631

Inclusion and Exclusion Criteria

The inclusion criteria were systematic reviews with or without meta-analysis comparing the outcomes between the laparoscopic and robotic surgeries for treatment of patients with localized PC. Only studies in English, Spanish or Portuguese were included. No time restraints were employed. Exclusion criteria were studies comparing only laparoscopic and open or robotic and open surgeries; animal studies; unrelated articles; clinical trial articles, case reports and letters to the editor.

Search Strategy

The Virtual Health Library (VHL) system was used to find standardized descriptors. The terms researched were: "prostatectomy", "minimally invasive surgical procedures", "laparoscopic surgery" and "robotic surgery". The MeSH terms used were "prostatectomy", "minimally invasive surgical procedures", "laparoscopy" and "robotic surgical procedures". Other free terms were also included: (robotic OR robot OR da vinci OR "Robotic Surgical Procedures"[Mesh] OR remote surgery OR remote operation) AND ("prostatectomy"[MeSH Terms] OR "prostatectomy"[All Fields] OR "prostatectomies"[All Fields]) AND ("Laparoscopy"[Mesh] OR laparoscopic prostatectomy), which initially resulted in 3132 results.

The research was conducted using the PubMed database. The studies were filtered to include only systematic reviews and meta-analyses and only in English, Portuguese or Spanish, which changed the number of results to 159 publications. The systematic research of the literature was performed until November 23, 2024. All relevant studies were assessed independently by two authors (RL and MHLS), with discrepancies resolved by a third author (MM).

Selection of Studies

After reading the titles and abstracts of the 159 published papers, an initial screening was made for the selection of the relevant papers. Duplicate papers were deleted in this step. Subsequently, the papers were fully read for the selection of the studies. The selected papers were collected and stored in the Mendeley software. Fig. 1 depicts the flow diagram of the study selection process.

Data Extraction and Analyses

Data was extracted by two authors independently, using a standardized online spreadsheet. No statistical conversions were done. When data was unavailable, its absence was accounted for when critically appraising results. All included studies were eligible

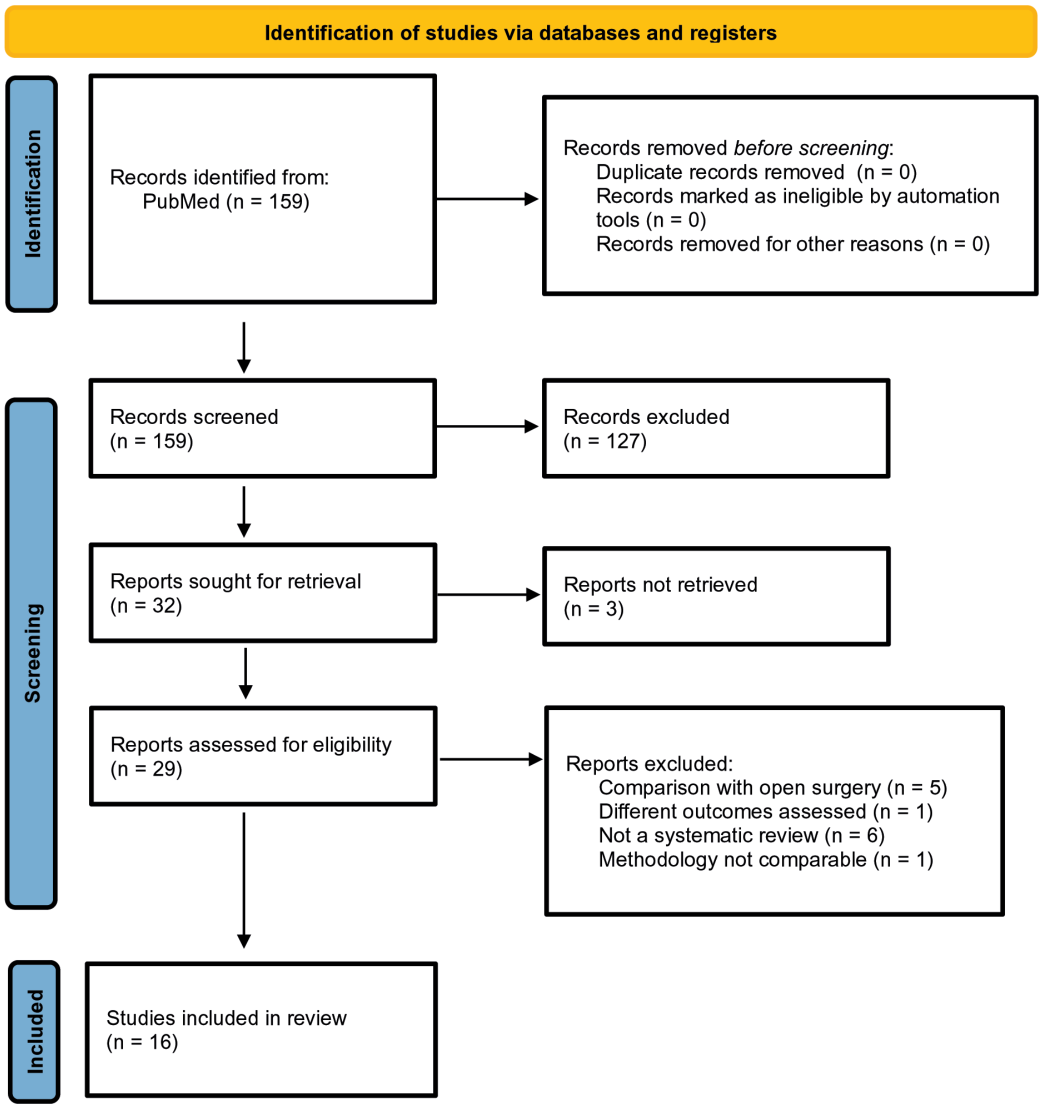

Figure 1: PRISMA Flow Diagram of the study selection process

for qualitative analysis and indirect comparison via tabulation of findings. Risk of bias analyses were conducted according to the original risk of bias evaluations on the included studies.

Results

Initially, 159 articles were found. With no duplicate papers, titles and abstracts were analyzed for all articles and 127 irrelevant studies were excluded. At this point, the studies were fully read to conduct the final selection of the papers and, finally, 16 studies were included.

The meta-analyses included a variable number of clinical trials, ranging from 2 to 54. The two meta-analyses that included only two studies had chosen to include only the best scientific, randomized studies, which were only two at the time. The total number of patients included in the studies ranged from 232 to 16 830.[10,11]

Regarding the estimation of blood loss, five studies showed statistically significant benefit for robotic surgery, six studies showed no statistical difference between the two modalities, and the rest of the studies did not present data related to this outcome. Similarly, five studies showed a lower blood transfusion rate for robotic surgery, and five studies showed no difference between the two techniques.

Regarding the operative time, three meta-analyses found benefit for robotic surgery, in contrast to seven studies that showed similar operative times between the two techniques. Conversely, one review reported a benefit favoring laparoscopic surgery. Three studies showed a shorter hospital stay for patients submitted to RARP, and six studies did not notice a difference in hospitalization time.

Most reviews used the Clavien-Dindo classification to define and grade surgical complications. Eight meta-analyses showed no difference in the rate of complications between LRP and RARP, while three studies showed a statistically significant difference in the rate of complications, one of these only in the subgroup of more severe complications (Clavien-Dindo III to V), favoring robotic surgery.[12-14]

Regarding the occurrence of positive margins, four studies showed benefit for each of the modalities. Eight studies did not identify a statistically significant difference. Most of the papers depicted better urinary recovery rates for robotic surgery at various time points of the postoperative period (1, 3, 6 or 12 months), with no one revealing better results for laparoscopic surgery at any reported timepoint, while three showed no differences. Sexual recovery rates had similar findings.

The summary of findings of this systematic review can be seen in Table 1.

Discussion

The literature review depicted a tendency of studies to show benefit for RARP in terms of blood loss and transfusion rate. However, the results are not unanimous. There was an alternation between studies showing benefit for robotic surgery and studies showing absence of statistically relevant difference, but none showed better estimates of blood loss and blood transfusion rate for the pure laparoscopic modality.

Regarding operative time, some studies demonstrated benefits for RARP, possibly due to the shorter learning curve and other relative advantages of the robotic approach, such as improved movement precision, easier knot-tying and suturing, and reduced fatigue for the surgical team. Vallancien *et al* reported an operative time for LRP of 234 min (151 - 453) versus 182 min (141 - 250) for RARP.[28] While other studies showed no statistically difference in operative time, highlighting satisfactory time when any of the techniques are performed by skilled surgeons.

Minimally invasive techniques are generally associated with faster postoperative recovery and consequently shorter hospital stays. This review showed that some studies point to similarity in terms of length of hospital stay between the two techniques, which are both minimally invasive. Some tended towards robotic surgery in terms of shorter hospital stay, and the more frequent absence of pelvic drain in the robotic approach might play a role in this.

Regarding the rates of positive surgical margins, the results were the most discrepant. The occurrence of a positive margin may be related to several factors, in addition to the surgical approach itself, such as the surgeon's experience, local staging of the tumor, degree of preservation of the neurovascular bundle used, among others, which limits any conclusion on the influence of laparoscopic or robotic approaches on the results of oncological margins.

Regarding biochemical recurrence (BCR) rates, once again, no study depicted better results for the laparoscopic approach. Ficarra *et al*[29] demonstrated that BCR was significantly influenced by surgical experience, clinical tumor size, and anatomic tumor characteristics.

Recovery of urinary continence and sexual function has shown a trend more favorable to RARP in several meta-analyses, with odds ratios that, in some cases, almost double the chances of early recovery.[14,16] However, many of these studies presented significant heterogeneity and potential biases related to patient profile and surgical experience.

The analysis of the included studies clearly demonstrates that results remain conflicting, and higher-quality data are still needed to definitively establish the superiority of one surgical approach over the other. Most of the reviews included retrospective studies or prospective cohorts and non-randomized clinical trials. The number of randomized clinical trials is still very low. The high statistical heterogeneity observed in several outcomes (with I^2 often higher than 75%) limits the robustness of the conclusions and highlights the need for caution in interpreting the results. There are several complicating factors that explain the difficulty in performing a higher quality study comparing surgical modalities in radical prostatectomy. First, it encounters the difficulty of randomization because patients hardly accept not participating in the decision of the surgical modality, and usually opt for the approach they understand to be more "modern", in case they have the possibility of choice. Another very important factor is regarding the experience of the surgeon. Most of the included meta-analyses did not mention the criteria adopted to validate the participation of surgeons in the respective trials, as well as the reasons for their choices. It is already known that laparoscopic radical prostatectomy requires a lot of effort and time from surgeons to become skilled in the surgical technique, and that this learning curve is shortened when replaced by the robot-assisted approach.[28]

Additionally, divergencies in publication timepoints should not be overlooked. Most of the included studies in this review were undertaken more than a decade ago; since then, substantial technological improvements have occurred in both robotic and laparoscopic platforms. Innovations such as enhanced three-dimensional visualization, newer robotic consoles with improved ergonomics, and refinements in laparoscopic instrumentation may influence perioperative and functional outcomes. This temporal gap limits the external validity and applicability of some findings to current clinical practice. Furthermore, while robotic prostatectomy entails higher procedural costs, the potential for improved functional recovery, particularly in urinary continence and sexual function, raises questions about its cost-effectiveness compared to laparoscopy. Robust prospective studies incorporating contemporary technology and comprehensive health economic analyses are warranted to better clarify the balance between clinical benefits and financial implications.

Table 1 – primary outcomes

Study	Country	Number of studies[a]	Total patients	Blood loss (ml)	Blood transfusion	Operative time (min)	Hospital stay (d)	Clavien-Dindo Complications	
								I-II	III-V
Du 2018 (15)	China	33	16830	**RARP** < LRP SMD 0.31 [0.01, 0.61] [b]	**RARP** < LRP OR 5.32 [1.29, 21.98] [b]	**RARP** < LRP SMD 0.71 [0.18, 1.25] [b]	-	-	-
Steffens 2017 (11)	Australia	2	248	RARP = LRP MD -81.36 [-81.36, 17.16]	-	RARP = LRP MD 9.50 [-0.67, 19.67]	RARP = LRP MD 0.20 [0.92, 0.52]	RARP = LRP RR 1.50 [0.75, 3.01]	
Lee 2017 (12)	South Korea	26	9412	-	**RARP** < LRP RR 0.70 [0.54, 0.91]	**RARP** < LRP RR -18.74 [-32.15, -5.33] [b]	RARP = LRP MD -1.13 [2.93,0.67] [b]	RARP = LRP RR 0.87 [0.46, 1.64] [b]	**RARP** < LRP RR 0.44 [0.23, 0.85]
Huang 2016 (16)	China	24	9178	**RARP** < LRP MD 75.94 ml [6.95, 144.94]	**RARP** < LRP OR 2.08 [1.33, 3.26]	RARP = LRP MD -5.31 min [-19.41, 8.80]	RARP = LRP MD 0.07 [-0.13, 0.26]	RARP = LRP OR 1.13 [0.74, 1.74]	
Allan 2015 (10)	Australia	2	232	-	-	-	RARP = LRP		
Robertson 2013 (17)	United Kingdom	8	3830	-	RARP = LRP OR 0.71 [0.31, 1.62]	-	-	-	-
Moran 2013 (18)	Ireland	9	2166	RARP = LRP WMD -78 [-199, 43]	RARP = LRP 0.7 [0.31, 1.39]	RARP = LRP -24 [-53, 5]	**RARP** < LRP WMD -0.7 [-1.2, -0.1] [b]	RARP = LRP RR 1.0 [0.56, 1.62]	
Novara 2012 (19–22)	Multiple	8	1400	RARP = LRP WMD 54.21 [-75.17, 183.59] [b]	**RARP** < LRP OR 2.56 [1.32, 4.96]	RARP = LRP WMD 34.78 [-1.36, 70.93] [b]	-	RARP = LRP OR 1.4 [0.73, 2.69] [b]	
Tewari 2012 (13)	United States	7	-	**RARP** < LRP WMD 127.8 [95.4, 160.2]	RARP = LRP WMD 1.02 [-0.1, 2,1]	-	**RARP** < LRP WMD 1.04 [0.3, 1.8]	**RARP** < LRP WMD 6.74 [2.6, 10.9]	
Ramsay 2012 (23)	United Kingdom	54	11720	-	RARP = LRP OR 0.71 [0.31, 1.62]	**RARP** < LRP MD -12.4 [-16.5, -8.1]	-	RARP = LRP	
Heer 2011 (24)	United Kingdom	-	-	RARP = LRP	-	-	RARP = LRP	RARP = LRP RR 1.83 [0.78, 4.31]	
Parsons 2008 (25)	United States	19	3839	-	RARP = LRP	-	-	-	-
Wang 2024 (26)	China	4	616	**RARP** < LRP WMD -31.04 [-54.57, -7.51]	-	RARP = LRP WMD 16.88 [-69.4, 103.2]	-	-	-
Ma 2023 (14)[c]	China	4	838	RARP = LRP WMD 2.95 [-56.84, 62.74] [b]	-	RARP > **LRP** WMD 5.64 [0.34, 10.9]	-	RARP = LRP OR 0.87 [0.60, 1.25]	
Ma 2023 (14)[d]	China	42	5431	**RARP** < LRP WMD -71.99 [-99.37, -44.61] [b]	**RARP** < LRP OR 0.44 [0.35, 0.56]	RARP = LRP WMD 3.00 [-14.0, 20.0] [b]	**RARP** < LRP WMD -0.41 [-0.68, -0.13] [b]	**RARP** < LRP OR 0.72 [0.54, 0.96]	
Carbonara 2021 (27)	Italy / United States	16	13752	RARP = LRP MD -53.1 [-116.1, 9.7]	-	RARP = LRP MD -16.3 [-46.3, 13.6]	RARP = LRP	-	RARP = LRP OR 0.61 [0.36, 1.04]

Notes:

SMD = standard mean differences; OR = odds ratio; ORs = combined odds ratios; MD = mean difference; WMD = weighted mean differences; RR = relative risk

a In cases where the review included articles comparing RARP also with open prostatectomy, the number of articles included in the review and the number of patients was changed to include only the studies comparing RARP and LRP

b Results with high level of heterogeneity ($I^2 = 75\%$)

c Results of only the randomized clinical trials

d Results of only the non-randomized studies

Bold: surgical modality with statistically significant benefit ($p < 0.05$)

Table 1 – primary outcomes (continuation)

Study	Positive surgical margin	Biochemical recurrence at 12 months	Urinary continence recovery rate				Sexual potency recovery rate		
			At 1 month	At 3 months	At 6 months	At 12 months	At 3 months	At 6 months	At 12 months
Du 2018 (15)	**RARP** < LRP OR 1.27 [1.10, 1.46]	-		**RARP** > LRP OR 0.66 [0.55, 0.78]				**RARP** > LRP OR 0.55 [0.31, 0.95]	
Steffens 2017 (11)	RARP = LRP RR 1.39 [0.81, 2.41]	-	-	RARP = LRP RR 0.21 [0.02, 2.68]	-	RARP = LRP RR 0.93 [0.86, 1.00]	-	RARP = LRP RR 0.47 [0.19, 1.19]	**RARP** > LRP RR 0.56 [0.32, 0.96]
Lee 2017 (12)	RARP > **LRP** RR 1.23 [1.05, 1.46]	**RARP** < LRP RR 0.65 [0.55, 0.78]	-	-	-	**RARP** > LRP RR 0.43 [0.31, 0.60]	-	-	**RARP** > LRP RR 1.38 [1.11, 170] [b]
Huang 2016 (16)	RARP > **LRP** OR 0.88 [0.78, 0.99]	RARP = LRP OR 1.15 [0.12, 10.64]	-	**RARP** > LRP OR 1.73 [1.30, 2.32]	**RARP** > LRP OR 2.20 [1.60, 3.04]	**RARP** > LRP OR 1.62 [1.20, 2.17]	**RARP** > LRP OR 2.20 [1.48, 3.28]	**RARP** > LRP OR 2.34 [1.43, 3.84]	**RARP** > LRP OR 2.20 [1.41, 3.43]
Allan 2015 (10)	RARP = LRP RR 1.39 [0.81, 2.41]	RARP = LRP RR 1.01 [0.91, 1.12]		**RARP** > LRP RR 1.14 [1.04, 1.24]				**RARP** > LRP RR 1.51 [1.19, 1.92]	
Robertson 2013 (17)	**RARP** < LRP OR 0.69 [0.51, 0.96]	RARP = LRP OR 0.89 [0.24, 3.34]	-	-	-	RARP = LRP	-	-	-
Moran 2013 (18)	RARP = LRP	-	-	-	-	**RARP** > LPR RR 1.09 [1.02, 1.17]		RARP = LRP RR 1.49 [0.60, 3.73]	
Novara 2012 (19–22)	RARP = LRP OR 1.12 [0.81, 1.55]	RARP = LRP HR 0.5 [0.2, 1.3]	-	-	-	**RARP** > LPR OR 2.39 [1.29, 4.45]	-	-	-
Tewari 2012 (13)	**RARP** < LRP MD 3.02 [1.1, 5.0]	-	-	-	-	-	-	-	
Ramsay 2012 (23)	**RARP** < LRP OR 0.69 [0.51, 0.96]	RARP = LRP OR 0.89 [0.24, 3.34]	-	-	-	RARP = LRP OR 0.55 [0.09, 2.84]	-	-	-
Heer 2011 (24)	RARP = LRP RR 0.97 [0.65, 1.46]	-	-	-	-	-	-	-	
Parsons 2008 (25)	RARP = LRP	-	-	-	-	-	-	-	-
Wang 2024 (26)	RARP = LRP OR 1.11 [0.74, 1.68]	RARP = LRP OR 0.61 [0.21, 1.83]	-	RARP = LRP OR 1.01 [0.63,1.63]	RARP = LRP OR 0.96 [0.47,1.93]	-	RARP = LRP OR 1.33 [0.88, 2.01]	RARP = LRP OR 0.76 [0.36, 1.59]	-
Ma 2023 (14)[c]	RARP > **LRP** OR 1.48 [1.01, 2.18]	RARP = LRP OR 1.40 [0.85, 2.32]	**RARP** > LRP OR 2.14 [1.25, 3.66]	**RARP** > LRP OR 1.51 [1.12, 2.02]	**RARP** > LRP OR 2.66 [1.31, 5.40]	**RARP** > LRP OR 3.52 [1.36, 9.13]	**RARP** > LRP OR 4.25 [1.67, 10.82]	**RARP** > LRP OR 3.52 [1.31, 9.44]	**RARP** > LRP OR 3.59 [1.78, 7.27]
Ma 2023 (14)[d]	RARP > **LRP** OR 1.12 [1.03, 1.22]	**RARP** < LRP OR 0.78 [0.66, 0.92]	**RARP** > LRP OR 1.89 [1.58, 2.26]	**RARP** > LRP OR 1.53 [1.36, 1.71]	**RARP** > LRP OR 1.71 [1.49, 1.98]	**RARP** > LRP OR 1.38 [1.20, 1.58]	**RARP** > LRP OR 2.00 [1.69, 2.36]	**RARP** > LRP OR 2.43 [2.02, 2.92]	**RARP** > LRP OR 1.63 [1.09, 2.43]
Carbonara 2021 (27)	RARP = LRP OR 1.04 [0.78, 1.39]	**RARP** < LRP OR 0.52 [0.43, 0.63]	-	-	-	**RARP** > LRP OR 0.38 [0.18, 0.8]	-	-	**RARP** > LRP OR 2.16 [1.23, 3.78]

Notes:

SMD = standard mean differences; OR = odds ratio; ORs = combined odds ratios; MD = mean difference; WMD = weighted mean differences; RR = relative risk

a In cases where the review included articles comparing RARP also with open prostatectomy, the number of articles included in the review and the number of patients was changed to include only the studies comparing RARP and LRP

b Results with high level of heterogeneity (I^2 = 75 %)

c Results of only the randomized clinical trials

d Results of only the non-randomized studies

Bold: surgical modality with statistically significant benefit ($p < 0.05$)

There is also a large number of articles which have been conducted between 2010 and 2015, contrasting with a relative reduction in publications in the last years. Perhaps this may be explained by the difficulty of performing these investigations and by the acceptance and dissemination of the robotic technique even without the definitive proof of superiority.

Conclusion

In summary, robot-assisted radical prostatectomy demonstrates several practical advantages over laparoscopic prostatectomy, including improved ergonomics, enhanced dexterity, and potentially faster recovery of urinary continence and sexual function. However, perioperative and oncological outcomes remain largely comparable between the two techniques, and significant heterogeneity across studies limits definitive conclusions regarding superiority. Moreover, the higher costs associated with robotic surgery pose important considerations for health systems. Future high-quality randomized trials incorporating contemporary surgical platforms and robust cost-effectiveness analyses are essential to better inform surgical decision-making and optimize patient outcomes.

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