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根治性前列腺切除术的演进与三种术式比较

李恒平，张矛，张向向，王向荣，李海洋，刘扬，李选鹏，周鹏，马榕

（甘肃省人民医院泌尿外科　甘肃　兰州　730000）

摘要　根治性前列腺切除术是治疗局限性前列腺癌的一种手术方式。近年来，随着新的医疗设备和手术技术的出现，根治性前列腺切除术发生了革命性的演变，其手术方式的演变经历了3个阶段：开放手术，微创腹腔镜介入和机器人辅助手术。腹腔镜或机器人辅助根治性前列腺切除术（RARP）能够改善患者病情，且不影响其肿瘤学预后。特别是RARP，由于机器人手术系统的优势可以改进手术技术实现精细操作，能够短期和长期维持尿控和性功能。此外，研究表明在过去二十年中，它与降低术后发病率相关。本文旨在回顾从开放手术到机器人辅助根治性前列腺切除术的相关文献，对新术式的优越性进行了分析，并比较了三种术式的优缺点，以期为泌尿外科医师在考虑采用手术治疗局限性前列腺癌时提供指导。

关键词　前列腺癌；机器人辅助根治性前列腺切除术；腹腔镜根治性前列腺切除术；开放根治性前列腺切除术

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Critical evolutions in radical prostatectomy and the comparison of three surgical modalities

LI Hengping, ZHANG Mao, ZHANG Xiangxiang, WANG Xiangrong, LI Haiyang, LIU Yang, LI Xuanpeng, ZHOU Peng, MA Rong

(Department of Urology, Gansu Provincial Hospital, Lanzhou 730000, China)

Abstract　Radical prostatectomy is a commonly used surgical method in cases of localized prostate cancer. In recent years, with the advent of new medical technologies and surgical techniques, the evolution of radical prostatectomy has revolutionized, especially in robot-assisted radical prostatectomy (RARP). The evolution of surgical approaches for radical prostatectomy has occurred in three stages: open surgery, laparoscopic intervention, and robot-assisted surgery. Regarding the functional recovery of patients who underwent laparoscopic radical prostatectomy or RARP, with the improvement of disease conditions, oncological prognosis of patients was not compromised. Particularly, RARP boasts distinguished novel techniques and approaches for maintaining urinary continence and sexual function in the short- and long-term. In addition, studies in the last two decades have shown its correlation with decreasing postoperative morbidity. In this paper, the available literatures related to the surgical approaches ranging from open surgery to RARP were reviewed, the superiority of any novel procedure was analyzed, and the advantages and disadvantages among the three modalities were compared, hoping to provide guidance to urologists when considering surgical approaches in the treatment of localized prostate cancer.

Key words　Prostate Cancer; Robot-assisted Radical Prostatectomy; Laparoscopic Radical Prostatectomy; Open Radical Prostatectomy

Prostate cancer (PCa) is the most common malignancy in the genitourinary system. Its morbidity in the past few decades has significantly increased. In 2021, in the United States, it was estimated that

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通讯作者：李恒平，Email：lhp3350@hotmail.com
Corresponding Author: LI Hengping, Email: lhp3350@hotmail.com
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the morbidity of PCa accounted for 26% of diagnosed cancer in men, where the mortality was 11%, second only to lung cancer[1]. In China, the morbidity of PCa has also increased drastically, affecting 34.2% of the total PCa cases in Asia[2-3]. Roughly, 90% of PCa is diagnosed as localized PCa, managed by surgery or radiation. Studies have shown that if diagnosed at an early stage, the life expectancy of localized PCa is about 99% over ten years in patients, however, the survival rate drastically decreases to 30% at 5 years in patients with metastases[4]. Hence, the therapy for localized PCa is significantly associated with long-term overall survival (OS) of patients. The modality that is currently best used to treat PCa is surgical intervention. Although observation data from several Meta-analyses have suggested that, compared with surgery, radiotherapy was associated with a high prostate cancer-specific mortality (PCSM)[5], whilst other studies found it was difficult to conclude which therapy could provide better outcomes[6]. Nonetheless, with the development of minimally invasive surgery (MIS), especially with the advent of robot-assisted radical prostatectomy (RARP), as well as the magnitude of researches on different surgical techniques, radical prostatectomy (RP) has a predominant benefit for patients with localized PCa, such as oncological eradication, functional rehabilitation, tissue structure preservation, length of hospital stay (LOS), and cosmetic efficacy. Although the development of RP experienced slow progression, roughly 100 years from its introduction to RARP now, it has many encouraging proven benefits.

Herein, in order to provide the best therapeutic efficacy for localized PCa patients and set forth the mainstream developing direction for RP in the future, reviewing the important evolutions of RP is essentially indispensable. Generally, the innovations of RP experienced three key stages, including open, laparoscopic and robotic procedures built around armamentarium[7]. No matter how widely used laparoscopic or robotic surgery is in Europe and Asia, Open RP (ORP) remains a primary option in the United States, with the exception of the widespread adoption of RARP, suggests it is also an effective approach[8]. More importantly, ORP is the best foundational surgery for all MISs which initially imitated the procedure of ORP. Laparoscopic RP (LRP) and RARP are both included in MIS. In the era of LRP, surgical techniques predominantly involved transperitoneal, extraperitoneal, and transvesical RP, however, due to limitations related to existing surgical equipment, MIS was difficult to be widely utilized. However, with the advent of robot-assisted laparoscopic surgery, the novel techniques of RARP were established by making use of its superiority, such as Retzius-sparing RARP (RS-RARP), Vattikuti Institute Prostatectomy (VIP) and partial prostatectomy based on the classification of modified techniques as well as intraperitoneal, extraperitoneal, perineal, and transvesical approaches to obtain surgical access[7, 9-13]. In brief, for the sake of the appropriate utilization, efficacious modification and novelty of the RP technique, urologists need to be proficient in the three modalities of RP.

1 Open radical prostatectomy

Open surgery is the primary foundational technique for every urologists since surgeons need to master the basic techniques in order to successfully perform ORP or open conversion during MIS[14]. ORP was firstly developed and summarized by Young H H in 1905 via a perineal access, i.e. radical perineal prostatectomy (RPP)[15-16]. Since then, although many urologists proposed certain modifications that promoted postoperative functional recovery and oncological eradications, RPP was not widely accepted for urologists due to its technical difficulty, most of whom have limited or no experience in performing surgery via perineal access. Furthermore, urologists were not well versed with dealing with related complications, such as urinary fistula and rectal injure[16-17]. Subsequently, open radical retropubic prostatectomy (ORRP) was described and popularized by Millin T in 1948 on the basis of his experience of extraperitoneal surgery via abdominal incision[18-19], which was widely adopted in light of urologists being familiar with anatomy, simultaneous dissection of pelvic lymph nodes, abdominal exploration, and local metastasectomy[20]. Compared to RPP, through a retrograde approach, ORRP was widely advocated at that time, but manipulation of the procedure that clearly expose visual planes causes the possibility of extrusion of cancer cells in the prostate gland may lead to distant metastasis. Therefore, the anterograde approach was preferred, as opposed to the retrograde approach. The anterograde approach, a method of ORRP minimizing the compression of the prostate

gland and leading to external diversion of malignant cells, was founded by Campbell E W in 1959[21]. Although the aforementioned procedures introduce a new era of open surgery, it is closely associated with excessive blood loss, prolonged LOS, and grievous complications that related to incontinence and impotence[22]. For the sake of reducing blood loss in operations and improving functional and oncological results after surgery, Reiner W C, et al., presented the completed ligation dorsal vein complex (DVC) minimizing blood loss[23]; moreover, it was shown that impotence after radical prostatectomy results from injury to the pelvic nerve plexus that provides autonomic innervation to the corpora cavernosa[24]. The drawbacks of postoperative impotence and intraoperative blood loss were resolved based on two previous breakthrough studies, which suggested that RP has a significant prospect in the field. Since then, large-scale trials were reported in many studies that demonstrated excellent oncological and functional outcomes via ORRP. Steiner M S, et al., reported that urinary continence after 1 year of follow-up in the 593 of 600 consecutive patients following an anatomical RP by 1 surgeon, the results showed that 547 (92%) patients achieved complete continence and 46 (8%) developed stress incontinence, but none of the patients suffered from complete incontinence[25]. Concurrently, clinical studies reported that urinary bother is almost non-existent in 93%~98% of men, 86% of men were potent, and 84% expressed no or few sexual issues in 18 months of follow-up[26]. Likewise, Kundu S D, et al., reported that potency, continence and complications were estimated in 3477 consecutive patients who underwent anatomical ORRP with a unilateral or bilateral nerve-sparing surgery (by 1 surgeon), after a minimum of 18 months of follow-up[27]. Sufficient erections for intercourse presented were achievable in 76% of pre-operatively potent patients who underwent bilateral nerve-sparing surgery and 53% who underwent unilateral or partial nerve-sparing surgery, recovery of urinary continence presented in 93% of all patients and was related with a younger age (P=0.001), but not in those who underwent nerve-sparing surgery. Other complications occurred in 9% of all patients, major complications included anastomotic stricture, hernias, and thromboembolic events[27]. Nerve-sparing ORRP has become the standard for patients with localized PCa. Barre C also reported outcomes of urinary continence and recovery of erection in 231 men with localized PCa who underwent radical retropubic prostatectomy using the procedure for high-quality preservation of sphincter function and high-precision retrograde isolation of the neurovascular bundles in the prostate zone[28]. Outcomes indicated that the rate of positive surgery margin (PSM) in confined cancer (pT_2) was 3.7%, fully continence occurred in 94% of men and recovery for satisfactory sexual intercourse occurred in 70.5% of men at 12 months of follow-up[28]. Although short-term satisfactory outcomes have been observed, long-term results of follow-up are paramount to properly evaluate clinical goals. Hull G W, et al., reported that the long-term progression-free survival (PFS) in a consecutive 986 localized PCa patients underwent ORRP, with a mean 53.2 months of follow-up (median 46.9, range 1 to 170). The study suggested that actuarial PFS was 78% and 75% at 5 and 10 years after the operation, respectively, mortality related to cancer was 2.4% and metastasis occurred in 15.8% of patients[29]. In the subgroup after 10 years of follow-up, ORRP resulted in 92.2% of progression-free probability in localized PCa and 52.8% in non-confined PCa, including 71.4% for only extracapsular extension and 37.% for seminal vesicle invasion without lymph node metastasis[29]. In order to evaluate more long-term oncological results, a study showed that 4478 patients underwent nerve-sparing ORRP during a median 10–year of follow-up (range 1 to 29), the overall 25–year progression-free, metastasis-free and cancer specific survival rates were 68%, 84% and 86%, respectively[30]. Finally, the clinical report suggested that excellent oncological results can be expected up to 30–year in early-stage PCa after meticulous radical surgical procedures[30]. In conclusion, the excellent short- and long-term outcomes of ORRP start a new era of RP and paved a way for MIS.

2 Laparoscopic radical prostatectomy

Laparoscopic radical prostatectomy (LRP), offering distinct visualization of the related anatomical structures, could reduce blood loss, alleviate postoperative pain, expedite convalescence, and improve oncological and functional outcomes. It is thus arguably the most meaningfully technical innovation in the past 3 decades. Initially clinical experience of laparoscopic radical retropubic prostatectomy (LRRP) with a transperitoneal approach

was reported by Schuessler W W in 1997[31]. The study, which is the case for vesicourethral anastomosis in particular, indicated that LRRP was feasible but technically challenging due to its average operative time of 9.4 hours. Contemporaneously, another extraperitoneal technique for LRRP was introduced by Raboy A[32-33]. In this study, the average operative time was reduced to 4.9 hours, based on incorporating with other modifications and using the harmonic scalpel and clips. In 1999, with the improvement of surgeon experience of using laparoscopic equipment, the average operative time was sharply cut down to about 4 hours[34]. Subsequently, numerous researches regarding extraperitoneal LRP (ELRP) were reported, and their findings suggested that ELRP, compared with transperitoneal LRP (TLRP), could offer less operative time, shorter length of stay, and lower rate of postoperative ileus[35]. Soon after the publication of these findings, the abundance of clinical trials indicated that LRP, compared with ORP, is safe, effective and similar in terms of oncological and functional outcomes. It is also beneficial in reducing rate and types of complications[36-40]. Therefore, LRP was considered as a golden standard in the treatment of localized PCa, in order to achieve an excellent trifecta, i.e. cancer control, continence, and potency after RP[41]. With the advent of specialized multichannel single-port approach device and pre-curved flexible-articulating laparoscopic equipment, single-port LRP (SP-LRP) via the umbilicus is an attractive procedure for improving cosmetic efficacy and releasing pain. Furthermore, feasibility and safety of single-port transvesical LRP (SP-TVLRP) has been confirmed in clinical practice[42]. These approaches have significant superiority since it could preserve the surrounding tissue structures of prostate, bladder, urethra and seminal vesicles, as well as its nerve supply that is related to urinary continence and sexual function[43-44]. Desai M M, et al., firstly described the feasibility of fulfilling SP-TVLRP with robotic surgical systems in two cadavers[45]. Subsequently, Gao X, et al., firstly launched a novel technique for SP-TVLRP, and evaluated its oncological and functional outcomes in 16 consecutive patients with localized PCa. Among the 16 patients, immediate continence was observed in 13 patients (0 pads/day), and mild urinary incontinence (2~3 pads/day) in 3 cases after catheter removal. All patients regained urinary continence 3 months after surgery, moreover, the mean PSA levels were less than 0.02 ng/mL during the follow-up, suggesting that SP-TVLRP is feasible for localized PCa and has a supernal clinical outcomes postoperatively[43]. Most importantly, their team attempted to compare the potency and continence of patients after SP-TVLRP with intrafascial endoscopic extraperitoneal RP (IEERP), suggesting that men underwent SP-TVLRP achieved refined and faster sexual and urinary recovery than IEERP (71.4% Vs 38.5% at 6 months postoperatively, 97.1% Vs 75% at 3 months, $P<0.01$)[46]. The excellent potency and continence after SP-TVLRP also certified the discovery of innervation and anatomy[23-24, 44, 47]. Taken together, LRP has been considered as an attractive approach and the gold standard in the treatment of patients with localized PCa. With that being said, pure LRP demands surgeons to invest plenty of time into mastering it, especially for vesicourethral anastomosis, which significantly decreases in PSM and biochemical recurrence (BCR) risk 2-year after the initial 350 cases of LRP[48].

3 Robot-assisted radical prostatectomy

The advent of RARP symbolizes the milestone of MIS. It not only provided better improvement of functional and oncological outcomes of patients with localized PCa, but also significantly shortened the learning curve for urological surgeons. In 2001, the RARP was first introduced by Blinder J who used a peritoneal approach. His experience indicated that the operative field was markedly refined by the robotic surgical system via a high-resolution camera with 3-D visualization, 10- or 15-fold magnification and infinitely variable positioning of the endoscope by the operating surgeon from a remote console. The handling of the laparoscopic tools is significantly flexible so as to easily manipulate the procedures and the surgery could be performed by the surgeon in a relaxed working position[49-50]. From then on, it was rapidly adopted by many surgeons due to the aforementioned advantages of a shorter learning curve and the elimination of physiological tremors. Currently, the use of RARP has comprised over 90% of all patients undergoing RP in the U.S., 43% in the UK, and 70% in Japan[7-10, 12-13, 51-54]. In order to reduce the risk of intraabdominal complications and achieve direct access to the surface of the prostate gland, extraperitoneal approach in RARP was presented by Gettman M T, et al.[55]. Certainly, compared with

intraperitoneal RARP (IRARP), a Meta-analysis revealed that extraperitoneal RARP (ERARP) could achieve similar oncological and functional outcomes, while delivering a faster operative time, shorter length of stay and lower morbidity of the peritoneal cavity organs[11]. Besides the classic techniques, during the robotic era, a variety of novel modified techniques and innovated surgeries were adopted to achieve a better trifecta, including RS-RARP, modified VIP, transvesical RARP (TV-RARP), single-port RARP (SP-RARP), and so forth[7, 9, 10, 12–13]. Galfano A firstly reported his experience of RS-RARP by passing through intrafascial plane[9], and then reported outcomes from their first 200 patients with ⩾ 1 year of follow-up[56]. Within 7 days after catheter removal, 90% of patients reached continence while 96% of patients achieved continence at 1 year after the operation; 52% of patients were potent 1 year after surgery; the overall PSM rate was 25.5% (51 of 200 patients). Subgroup analysis showed that the PSM rate was 14.7% in the pT_2, and 46% in the pT_3. In short, this clinical research confirmed the safety of RS-RARP and achieved high early continence and potency rates[56]. Recently, some randomized controlled trials and Meta-analysis have suggested that early continence recovery is superior in the RS-RARP over conventional RARP. Furthermore, its oncological outcomes and potency is similar or higher[57–60]. Meanwhile, the representative surgery via the anterior approach is modified VIP described by Menon M in 2003[61]. In 2007, for the sake of minimizing erectile dysfunction, while ensuring oncologic control, the VIP technique, along with the preservation of the lateral prostatic fascia (veil of Aphrodite), was introduced by Menon M. Data from 1142 patients, who underwent veil nerve-sparing surgery, had a follow-up of 12 months, suggested that the biochemical recurrence (BCR) rate was 2.3%. Moreover, 84% of patients achieved total urinary control. This study reported no postoperative erectile dysfunction during the 12 and 48 months of follow-up, and successful intercourse was achieved[10]. Although the technique spared the lateral veil of Aphrodite and significantly improved the trifecta, the super-veil nerve-sparing technique mainly spares the nerves from the 11–o'clock to the 1–o'clock position, which was also described by Menon M in an attempt to better improve the trifecta[62]. After a median follow-up of 18 months, the clinical trial identified that 94% of 85 patients experienced sexual intercourse successfully, after undergoing the super-veil nerve-sparing procedure, with a median score of 18 in sexual health inventory for men. Compared with the RS-RARP and the modified VIP procedure, TV-RARP intervention offers minimal trauma and maximizing preservation through the vesical lumen with no need to dissect the surrounding tissue of prostate gland and bladder, which may lead to injury to the pelvic neuronal innervation. A series of clinical researches on TVLRP showed excellent results, but it is extremely difficult compared with the robotic procedure. Hence, Zhou X C, et al., reported the initial outcomes of TV-RARP in 35 patients with localized PCa[12], the results indicated that urinary continence was achieved in 32 patients after removing urethral catheters at day 7 after surgery, full continence was gained at day 14 after surgery, and positive PSM was found in 4 patients. Also, no BCR were observed in all patients after 12–month follow-up. Furthermore, to avoid unnecessary risk and ensure cosmetic efficacy, Kaouk J, et al., evaluated the functional and oncologic results from 20 patients who underwent single port TV-RARP (SPTV-RARP) using SP robotic surgical platform via bladder lumen[63]. All procedures were successfully completed, 75% patients had full continence 2 days after catheter removal, 85% had full continence 10 days after catheter removal, and PSM was found in 15% patients. With the development of MRI and targeted prostate biopsy, the localization of PCa could be precisely diagnosed so that partial prostatectomy was reported in a few studies[7, 64]. Recently, single-port robot-assisted transvesical partial prostatectomy was performed on 9 patients with localized low- and intermediate-risk PCa by a single surgeon using DaVinci SP robot[65]. Although a small series was included, this study identified the feasibility of SP transvesical partial prostatectomy with negative margin, promising continence and potent postoperatively and liable oncological control[65]. In conclusion, for clinical urologists, RARP is superior to LRP or ORP, especially for vesicourethral anastomosis, it further allows a more relax working position during the operation to achieve the trifecta, particularly in the small scope of the operative field.

4 Comparison of the three surgical modalities for radical prostatectomy

ORP, LRP and RRP are the main options in radical prostatectomy. Although the comparison of outcomes between LRP and ORP in early reviews identified a possible similar trifecta, in the light of lacking randomized control trials, no explicit conclusions could be drawn[66]. However, with the gradually increased clinical trials, the outcomes of ORP were compared with LRP, which verified that there was no significant difference in oncological outcomes, but LRP was associated with less blood loss and a higher urinary continence. However, emergency room visits and readmissions in LRP were higher than ORP[67]. Conversely, Caras R J, et al., showed that the incidence of overall morbidity was significantly decreased in men who underwent LRP compared with ORP at day 30 after surgery[68]. As shown in table 1. More interestingly, trainee involvement was associated with a higher incidence of intraoperative blood loss and serious complications (P<0.001), but operative times decreased with trainee experience for both procedures. This also clarified that the reason why early reviews indicated that higher overall complications were observed in LPR[68].

The results of prospective, randomized controlled phase 3 study of RARP, compared with ORRP, have shown to be the same in men who were newly diagnosed with localized PCa at 12 weeks and 24 months postoperatively. However, earlier results showed that RARP had minimally invasive benefits, less bleeding during the operation, shorter hospital stay, and less pain in the first week after surgery[69-70]. Long-term functional and oncological outcomes were reported in a prospective, controlled, nonrandomized trial by comparing RARP with ORRP in multi-institutions of Swedish, suggesting that urinary incontinence was not statistically different 8 years after surgery between RARP and ORRP, but erectile dysfunction and PCSM was significantly lower in RARP than ORRP at 8 years after surgery (66% Vs 70%, adjusted *RR*=0.93, 95% *CI*: 0.87 to 0.99; 40/2699 Vs 25/885, adjusted *RR*=0.56, 95% *CI*: 0.34 to 0.93). Moreover, the risk of PSM, BCR, and PCSM were lower in the group with high D'Amico risk for RARP versus open RRP[71]. Recently, Wang Y, et al., compared the overall survival in an epidemiologic study involving 37 645 men who received RALP and 12 655 men who received ORP. At the 60.7 months follow-up, the 5 years all-cause mortality showed a statistically significant reduction after RARP than after ORP[72]. Hagman A, et al., clarified the disadvantages and advantage of RARP and LRP, functional recovery and oncological results in different risk-groups of men who underwent RARP and ORRP was reported in his study. In men of the high-risk groups, significantly higher rates of urinary continence recovery was found in ORRP compared to RARP (66.1% Vs 60.5%, *RR*=0.85, 95% *CI*: 0.73 to 0.99), while PSM had a frequent recurrence rate in ORRP compared to RARP at 24 months. BCR was significantly more common in ORRP than RARP at 24 months[73]. Urinary incontinence is undeniably a significant side effect and significantly impacts QoL. A study compared RARP with ORRP, in a matched-pair trial with 241 men per group, showed markedly better continence was present in the RARP group than the ORRP group (*HR*=1.42, 95% *CI*: 1.18 to 1.69, P<0.001). Additionally, in order to reduce the possible impact of learning curve on functional results, the first 100 men who underwent RARP were excluded in the research[74]. Although some of the comparative studies, associated with ORP and RARP, suggested patients in both groups having a similar long-term health-related QoL, while patients who underwent RARP had less pain, shorter mean LOS, fewer postoperative complications and faster recovery of potency and continence[75-76]. As shown in table 1. Stenosis of the vesicourethral anastomotic site was also the main complication in spite of a lower incidence rate. The large prospective nonrandomized study showed that symptomatic stenosis was found in

Table 1 Comparison between ORP and LRP in different studies

Researchers	Type of comparison	Year	Blood loss (mL)	Emergency room visits(%)	Readmissions (%)	Overall morbidity (cases)
Touijer K[67]	ORP Vs LRP	2008	315±186 Vs 1267±660	15 Vs 11	4.6 Vs 1.2	
Caras R J[68]	ORP Vs LRP	2014				8391 Vs 2278

1.9% of 3706 evaluable male patients in 24 month, and the risk was 2.2 times higher after RRP than after RALP (*RR*=2.21, 95% *CI*: 1.38 to 3.53). Meanwhile, subsequent incontinence was twice as common in men who had stenosis (*RR*=2.01, 95% *CI*: 1.43 to 2.64)[77].

The available data suggested that there is no difference in oncological results between RARP and ORRP. However, as far as PSM is concerned, the multinational, multi-institutional study of 22 393 men after RP showed that PSM rates were the lowest in the RARP group, followed by the LRP group and the ORP group before adjusting data. In addition, the PSM rates were observed to be lower in MIS cohorts than ORP cohorts (*OR*=0.76, *P*<0.001), with no differences between robotic and laparoscopic cohorts (*OR*=0.99, *P*=0.88)[78]. Especially for less experienced surgeons with respect to learning curve, RARP offered a predominant short learning curve compared with LRP[79]. WU S Y, et al., compared postoperative complications of RARP, LRP and ORRP in men of Chinese Taiwan, and observed a faster discharge in the RARP group than those in the ORRP (*P*<0.001) and LRP group (*P*=0.01)[80]. Some studies revealed a higher cost in the RARP group compared with the LRP or ORP group[81]. However, the study conducted by Ploussard G, et al., involved 19 018 men of France, including 21.1% of ORP, 27.6% of LRP and 51.3% of RARP, it was found that RARP had lower complication rates (*P*<0.001), shorter LOS (*P*<0.001), and lower readmission rates (*P*=0.004) in terms of early postoperative outcomes. Meanwhile, higher costs related to the robotic surgical system appear to be balanced by patient care improvements and reduced direct costs due to shorter LOS[82]. In order to assess the cost of RARP, latest systematic reviews evaluated cost-effectiveness of RARP by comparing with ORP and LRP, suggesting that RARP had a higher cost and better effectiveness than ORP and LRP in most studies[83].

In summary, at present, regardless of the tumor control, functional recovery, or the postoperative complications, RARP is considered as an effective and efficacious procedure, although it is related to slightly higher costs based on the aforementioned research findings.

5 Future perspectives

RP has been greatly developed with the innovation of medical equipment and the popularization of novel techniques. Also, oncological and functional outcomes were significantly improved in men with localized PCa who underwent RP. However, the differences were also observed in the three modalities. In brief, the objective of RP is principally to reach a perfectly refined trifecta while preserving functional tissues and nerves, as well as reducing incidence of morbidity and improving cosmetic efficacy. According to the above evidences, combined with the increased incidence of early-stage PCa owing to the screening of PSA, accurate diagnosis of MRI and precise biopsy, RARP might be a widely tailored approach in view of its flexible and meticulous manipulation in the small scope of the operative field, and great postoperative benefits, such as higher rates of continence and potence, lower mortality, and good cometic efficacy, particularly via TV-RARP, RS-RARP, and the modified VIP, SP-RARP approaches. Unquestionably, the slightly higher cost was observed in the case of Da Vinci surgical robot (Intuitive Surgical, Inc.). Nevertheless, with the advent of other medical robots [84–85], costs of robotic surgery will be definitely

Table 2 Comparison between RARP and ORP in different studies

Researchers	Type of comparison	Year	Blood loss (mL)	PSM	PCSM	BCR	5–year all-cause mortality	Mean LOS
Lantz A[71]	RARP Vs ORP	2021		21% Vs 34%	14/220 Vs 11/77	51% Vs 69%		
Wang Y[72]	RARP Vs ORP	2021					3.9% Vs 5.5%	
Hagman A[73]	RARP Vs ORP	2021		23.5% Vs 46.8%(24 months)	No[a]	6.6% Vs 9.8%(24 months)		
Chang P[75]	RARP Vs ORP	2022	192 Vs 805					1.6 Vs 2.1

Note: a. No significant difference

decreased. Hence, RARP will be an effective and efficacious procedure and widely accepted by surgeons worldwide, especially for its preservation of functional tissues and nerve sparing. However, more long-term follow-up studies on RARP are needed to verify these findings.

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