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Review

The current status of robot-assisted radical prostatectomy

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Abstract

Robot-assisted radical prostatectomy (RARP) is a rapidly evolving technique for the treatment of localized prostate cancer. In the United States, over 65% of radical prostatectomies are robot-assisted, although the acceptance of this technology in Europe and the rest of the world has been somewhat slower. This article reviews the current literature on RARP with regard to oncological, continence and potency outcomes–the so-called 'trifecta'. Preliminary data appear to show an advantage of RARP over open prostatectomy, with reduced blood loss, decreased pain, early mobilization, shorter hospital stay and lower margin rates. Most studies show good postoperative continence and potency with RARP; however, this needs to be viewed in the context of the paucity of randomized data available in the literature. There is no definitive evidence to show an advantage over standard laparoscopy, but the fact that this technique has reached parity with laparoscopy within 5 years is encouraging. Finally, evolving techniques of single-port robotic prostatectomy, laser-guided robotics, catheter-free prostatectomy and image-guided robotics are discussed.

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1 Introduction

Urologists have led the way in clinical robotic surgery for almost 20 years. Robot-assisted radical prostatectomy (RARP) is the most common robotic procedure worldwide, particularly in the United States, where there are currently more than 550 da Vinci robotic systems in operation. Although RARP constituted only 10% of the total volume of radical prostatectomies performed by American urologists 2 years ago, the proportion has increased to more than 65% in 2008–2009. In parallel, the proportion of laparoscopic radical prostatectomies (LRPs) has decreased to 1%. Many surgeons argue that this is just a reflection of marketing. We recall a similar debate surrounding open radical prostatectomy (ORP) 15 years ago, but now this procedure is widely regarded as the 'gold standard' and is the only one that has been proven in a randomized trial to reduce mortality compared with watchful waiting [1].

The acceptance of RARP in Europe and elsewhere in the world has been slower for three main reasons. Firstly, the experience gained in LRP has yielded excellent results. Second, there are high costs in setting up and maintaining a robotic system, which is pertinent in poorer nations. Finally, the volume–outcome relationship is an issue, whereby smaller centers have found it difficult to overcome their learning curves.

Despite these factors, surgeons who are experienced in both ORP and LRP can make smooth transitions to robotics [2, 3] and even improve on their results. This article reviews the current literature with regard to the outcomes of RARP, specifically the 'trifecta' of margins, continence and potency. This article also describes exciting new developments in the field.

2 Oncological outcomes

Some urologists experienced in ORP initially found

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little added benefit with RARP when comparing surgical outcomes such as blood loss, hospital stay and margins in a nonrandomized manner. Subsequently, with increasing experience, they have reported subtle improvements, such as a decrease in their margin rates. Smith *et al*. [4] analyzed the results of 1 747 patients undergoing radical prostatectomy (RARP in 1 238 and ORP in 509), selecting the last 200 consecutive patients in each group. The overall incidence of positive surgical margins (PSMs) was significantly lower in RARP compared with ORP (15% *vs.* 35%), and in both groups the apex was the most common site of PSMs. Patients who underwent ORP had higher risk features, which may have influenced these results.

Menon's team has presented the largest series of RARPs over a 6-year period. In Detroit, 2 766 consecutive men underwent RARP with up to a 5-year follow-up. The first 200 and most recent 200 patients were compared to determine the impact of experience and quality improvement. The mean surgical and robotic console times were 154 and 116 min, respectively. Estimated blood loss was 100 mL, and 96.7% of patients were discharged within 24 h of surgery. At a median follow-up of 22 months, 7.3% of men had a prostate-specific antigen (PSA) recurrence. The 5-year actuarial biochemical free survival rate was 84%. This review confirmed that with RARP, further improvements in pathologic and functional parameters can be achieved with increasing experience [5].

Despite these encouraging results and the inclusion of RARP in the NICE (National Institute of Clinical Excellence, UK) guidance on LRP in November 2006, the use of RARP in the United Kingdom and Ireland has been somewhat slow. The number of da Vinci systems in these countries has increased from 2 in 2003 to 12 in 2008. Furthermore, setting up a robotic program is a major undertaking for many surgical units and requires considerable expertise in RRP, ORP and LRP within the team [3]. In over 500 RRPs performed up to now, we have observed a steady decline in our PSM rate; in particular, early intraprostatic margins (resulting from inadvertent incisions into the prostate) due to lack of experience are now rare [6]. In the United Kingdom, a number of patients with localized prostate cancer still present with T3 disease. A comparison of outcomes between palpable and nonpalpable cancers showed an overall margin rate of 9%, with rates of 0% in pT2 and 21% in pT3 disease. These patients were carefully staged with magnetic resonance imaging (MRI) scans interpreted by an index radiologist, and frozen section biopsies were used to give patients with palpable disease the best chance of negative margins [7].

In a study of 216 consecutive RARPs by one fellowship-trained urological oncologist, the overall prevalence of PSMs was 14.8% and 5.4% for pT2 cancers. The factors that were associated with a greater risk of a PSM were the serum PSA level, PSA density, pathological Gleason grade and pathological stage. The overall and pT2 PSM rates remained constant throughout the series, indicating that the initial experience of performing RARP was not related to a greater risk of a PSM. A nerve-sparing procedure increased the risk of PSM in extraprostatic prostate cancer [8].

With increasing experience, RARP has been performed as a salvage procedure after failed cryotherapy, external beam radiation and brachytherapy. We described the first case of salvage RARP for local recurrence after external beam radiotherapy in a 50-year-old man who initially underwent combined external beam radiotherapy and hormonal treatment for stage T2a prostate adenocarcinoma. The patient was discharged on day 1 postoperatively. The histological analysis revealed an organ-confined tumor [9]. His PSA at 3 months was < 0.03 ng mL^{-1}. Kaouk *et al*. [10] performed salvage RARP on four patients for biochemical failure after radiation and/or brachytherapy. The mean operative duration was 125 min, the mean blood loss 117 mL and the mean hospital stay 2.7 days. Of the four patients, three had extracapsular extension and the first two had PSM, whereas none had rectal injuries. Three patients were continent within a month, whereas one continued to use 2–3 pads per day at 3 weeks. Salvage RARP remains an advanced procedure and is more difficult than operating in a virgin field.

Although most earlier articles have reported the results of experienced open surgeons making the transition to RARP, recent literature indicates that the introduction of RARP to an established LRP program can also reduce the PSM rate. In a cohort study, 197 patients had LRP and 50 patients underwent RARP. The overall PSM rates for LRP and RALP were 18% and 6%, respectively. For pT2 disease, the PSM rates were 12% and 4.7% for the LRP and RALP cohorts, respectively. For pT3/T4 disease, the PSM rates were 54% and 14% for LRP and RALP, respectively [11]. A cost-benefit analysis of RARP within a high-volume LRP program showed that 78 cases per year are needed to cover the costs of a purchased robot, whereas only 20 cases per year are needed if a robot is donated. Attaining a profit is not possible at centers performing fewer than 25 cases annually [12]. Clearly, these figures vary in different countries, but there is no doubt that although RARP is expensive it is the most cost-efficient procedure in high-volume centers.

3 Continence

Experienced open surgeons have worried about the reduction in early continence after RARP as compared with ORP. Similar concerns have been expressed over LRP, in which slowness to regain continence is perhaps because of

excessive traction on the urethra and surrounding pelvic floor tissues. A group from the Cleveland Clinic assessed the effectiveness of posterior reconstruction of Denonvilliers' musculofascial plate (PRDMP) in enhancing early continence after RARP and LRP. At 3 days after catheter removal, the percentage of patients with PRDMP who were continent was higher than that of those who were not reconstructed (34% *vs.* 3%). At 6 weeks, continence was again better in the PRDMP group (56% *vs.* 17%). The authors found that PRDMP leads to significantly higher early continence rates owing to improved maintenance of membranous urethral length [13].

Tewari and colleagues [14] described the technique of hitching up the bladder to the arcus tendineus (pubo-perineoplasty) and reported early continence rates of 30%, 60%, 88% and 95% at 1, 6, 12 and 18 weeks, respectively. They subsequently described total anterior and posterior (total) reconstruction around the urethra and its relationship to urethral length and continence. In 274 patients who underwent RARP, sphincter lengths were measured on magnetic resonance imaging (MRI) images as the distance from the prostatic apex to the penile bulb. Continence was defined as needing zero pads or a single liner. The continence rate in the shorter-sphincter group (< 14 mm) was 47% for the control technique (no reconstruction), 81% for anterior reconstruction and 90% for total reconstruction. The continence rate in the longer-sphincter group (> 14 mm) was 80% for the control technique, 83% for anterior reconstruction and nearly 99% for total reconstruction. Patients undergoing total reconstruction reported an earlier return of continence [15]. Similarly, Patel *et al*. [16] reported excellent continence results using a Walsh-like open surgical 'suspension suture' supporting the urethra to the pubic symphysis and reconstruction of the Denonvillier's fascia. The key seems to be to disturb the urethra and its surrounding musculature as little as possible. There is a tendency in LRP and RARP to cause traction injury to the urethra while trying to gain maximum length. The pneumoperitoneum also may have an adverse effect on sphincteric function. Surgeons performing RARP are continually looking at means of attaining earlier return to continence, and recent reports indicate that this is achievable.

4 Potency and quality of life

Early potency with or without a PDE5 inhibitor seems to be better with RARP than with ORP and LRP. With bilateral extended nerve sparing, the so-called 'Veil of Aphrodite,' ~90% of patients can eventually achieve intercourse [17]. This indicates that perhaps the better-vision and more versatile tools of RARP may yield better functional results [18] when open surgeons shift to this technique, but longer follow-up with validated questionnaires is essential to substantiate these results. In patients with palpable and more aggressive cancer requiring wide local excision, the technique of nerve advancement and end-to-end anastomosis has recently been described, and a small group of patients seemed to achieve earlier potency after this surgical modification to RARP [19].

It is important to avoid the use of thermal energy during nerve sparing. Ahlering and colleagues [20] reported the deleterious effects of cautery on potency and recently updated their results in patients in whom either monopolar or bipolar cautery had been used for nerve sparing. At 3, 9 and 15 months, only 8.3%, 14.7% and 43.2% were potent. However, at 24+ months, 50% of unilateral and 68% of bilateral nerve sparing were potent, with an average International Index of Erectile Function (IIEF-5) of 18.4 and erectile firmness of 75%–100% of baseline. This suggests that injury to the neurovascular bundles is generally not permanent and recovery can occur in up to 2 years. In our own experience with athermal nerve sparing, those with unilateral nerve sparing took 6–12 months longer to recover potency than those who underwent bilateral sparing. With patience and proactive 'penile physiotherapy,' erections can be achieved in most previously potent patients.

The physical component of the short form 12 (SF12) quality of life score seems to be higher after RARP at 1–6 weeks compared with ORP, but returns to baseline more rapidly after robotic surgery [21]. The UCLA-PCI SF-36v2 questionnaire was used to evaluate the urinary and sexual quality of life before and 1 year after RARP. On multivariate analysis, baseline urinary function was the only predictor of worsening of urinary function (odds ratio [OR] = 1.04, $P = 0.003$). A decrease in sexual function was predicted by baseline sexual function (OR = 1.03, $P = 0.0001$), baseline sexual bother (OR = 1.03, $P = 0.005$) and the technique of nerve sparing (OR = 0.31, $P = 0.05$). These authors found that better baseline sexual and urinary scores are generally associated with better postoperative outcomes [22]. This information can be very helpful in preoperative counseling of patients.

5 Recent advances

Laser-based RARP has been used in 10 dogs, using a prototype laser instrument. The potassium-titanyl-phosphate laser was used for dissection at 2–6 weeks, with intermittent use of the neodymium-doped yttrium aluminum garnet laser at 5 weeks for coagulating larger vessels. The peak intracavernosal pressure response to nerve stimulation was recorded as a percentage of the mean arterial pressure (ICP%MAP) before and after RARP. The ICP%MAP values before and after RARP were not significantly different. Two dogs had catheter-related complications and

one had an anastomotic leak. There were no laser-related complications [23].

In a pilot study, Tewari *et al*. [24] compared 10 patients having suprapubic diversion with a urethral splint with 20 patients having RARP with standard urethral catheterization. Patients with suprapubic diversion had less pain in the penile shaft and tip and an earlier return of continence.

The performance of a single-port trans-umbilical RARP has been reported in one patient with an operative duration of 5 h and an estimated blood loss of 250 mL. The hospital stay was 36 h and the margins of resection were negative. The angulation of the robotic instruments may make robotic surgery easier than laparoscopy during single-port access [25].

In an attempt to make robotic surgery more accurate, Thompson *et al*. [26] developed a computed tomography/MRI-based computerized algorithm for image-guided robotic surgery. This technology is accurate to < 1 mm and is soon to be tested in humans.

6 Conclusion

In the absence of randomized trials, the outcomes of RARP compared with ORP and LRP look favorable, but must be considered with a degree of caution. Although an effective transition can be made from ORP and LRP to RARP, the outcomes may be as much operator-dependent as technology-driven.

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