

REVIEW ARTICLE

Robotic assisted laparoscopic radical prostatectomy: a review of the current state of affairs

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Open retropubic radical prostatectomy is the gold standard treatment for localised prostate cancer. However, the procedure has inherent morbidity associated to it. Therefore, less invasive surgical techniques have been sought, one such alternative is robotic-assisted laparoscopic radical prostatectomy. The advantages provided by robotic technology have the potential to minimise patient morbidity while improving both functional and oncological outcomes. Although it is a recent technological advancement, robotic surgery has shown an increasing rate of adoption worldwide. Currently more than 30,000 patients have undergone this procedure worldwide. We present a review of the available literature on robotic-assisted laparoscopic radical prostatectomy.

Review criteria

- The information was gathered by an extensive MEDLINE (PubMed) search of the current available database over the subject.
- The primary author has already performed approximately 1200 Robotic-Assisted Laparoscopic Radical Prostatectomies.

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 None.

Introduction

In the USA, approximately 77,000 radical prostatectomies are performed yearly for the treatment of prostate cancer. The gold standard for treatment is open retropubic radical prostatectomy (RRP) which has demonstrated a reduction in disease-specific mortality for patients with localised prostate cancer (1). However, this treatment option is invasive and can potentially lead to significant morbidity. Therefore, patients and surgeons alike have sought out less invasive surgical options. One alternative is robotically assisted laparoscopic radical prostatectomy (RALP).

History of robotics in medicine

Initial applications of robotics in the field of medicine were with the use of rehabilitation devices and assistance for those with disabilities. In his pioneer experience, Dr David Gow created the first bionic arm in 1998 called the Edinburgh Modular Arm System (2). Robots posterior use was in helping individuals with severe disabilities to perform independent activities of daily living (The Winsford feeder) or integrate them into the workplace (RAID, Robot for assisting the integration of the disabled) (2).

The first robotic system applied in a surgical procedure was the PUMA 560, used to orient a needle for a brain biopsy under computerised tomography guidance (3). However, its use was discontinued because of safety issues. Later, a London group pre-

sented a robotic system called the PROBOT, used to aid in transurethral resection of the prostate (4). Following the same tendency, in 1992, International Business Machines (IBM) and associates developed a prototype for orthopaedic surgery. The ROBODOC was used to assist surgeons in milling out a hole in the femur for total hip replacements (5).

A new era was beginning, and the concept of tele-presence technology, that would allow the surgeon to operate at a distance from the operating room, was being intensively researched simultaneously at the Stanford Research Institute, Department of Defence, and the National Aeronautics and Space Administration (NASA) (6). The initial purpose was to create a prototype to suit the needs of the military, and the robotic arms were designed to be mounted on an armoured vehicle to provide immediate operative care in the battlefield. Soon thereafter, Intuitive Surgical acquired the prototype and commercialised the system called daVinci. At the same time, Computer Motion unveiled the first laparoscopic camera holder, Automated Endoscopic System for Optimal Positioning (AESOP). Computer Motion later created the Zeus surgical system, which is an integrated robotic system (6). In March 2003, a fusion of both companies was announced under the name of Intuitive Surgical Inc.

The daVinci robotic surgical system

The daVinci system's main components are: a control console that is controlled by the surgeon

For the Clinic

- Robotic-assisted laparoscopic prostatectomy is an evolving procedure being an alternative minimally invasive approach to prostate cancer.
- Initial results regarding continence, positive margins, hospital stay and erectile function are promising.

(Figure 1), and the surgical cart that consists of three or four arms (in a most recent version) (Figure 2) with a laparoscope and two or three surgical tools. The arms can be operated by the manipulation of two master controls on the surgeon's console. Tremor filtering, movement scaling, increased range of motion and ergonomics are advantages that can be achieved with the use of this system. No measurable delay has been noticed between the movement of the surgeon's controls and instruments response. The instruments used in the daVinci system allow the surgeon to roll, pitch, yaw and grip the laparoscopic tools using seven degrees of freedom.

The imaging system consists of two independent cameras in the dual-channel endoscopes that are fused, providing the surgeon with a 3D magnified image of the operative field.

After its first use in late 1990s, the daVinci system has been gaining an increased popularity and is now being used in many different fields of medicine, such as cardiothoracic surgery, general surgery, gynaecology and finally urology.

Minimally invasive prostate surgery and robotics

The concept of a laparoscopic approach to the treatment of prostate cancer is not new. In the early 1990s Schuessler et al. (7) described the laparoscopic pelvic lymph node dissection. Later, in 1992, Kavoussi and Clayman joined this group to describe their first successful laparoscopic radical prostatectomy (LRP) (8). The early results were less than promising, with prolonged operative times and no major advantages over conventional surgery (9).

However, in the late 1990s the procedure was revived as European surgeon's re-evaluated LRP and reported feasibility with results comparable with the open surgical approach (10–15). Despite this, a lack



Figure 1 Surgical console of the daVinci system



Figure 2 Surgical cart with four robotic arms

of widespread acceptance and utilisation of LRP has been observed, partly because of the steep learning curve of this procedure. Even in the hands of experienced laparoscopic surgeons the technical challenges imposed by the limitations of conventional laparoscopic instrumentation are formidable.

Menon, Guillonnet and Vallancien developed the robotic prostatectomy at Henry Ford Hospital in 2000 (16). Since that time we have seen a tremendous growth in adoption of the procedure. In the calendar year 2004 approximately 8500 cases were performed robotically and in 2005 the projection is 18,000 (personal communication with Intuitive Surgical). Therefore, in 2005 it is projected that 25% of all prostatectomies will be performed robotically. Worldwide over 30,000 robotic prostatectomies have been performed.

While the growth in adoption of this procedure has been rapid the procedure itself is still quite young and in the process of evolution. The long-term results are still to be determined but early results for functional and oncological outcomes are promising.

Operative outcomes

Operative time

It is difficult to compare operative times between various series because of variations in reporting of operative time to include set-up and/or pelvic lymph node dissection. The mean operative time for reported robotic series ranges from 141 to 540 min (16–28). In our experience, our operative time declined from a mean of 202 min for our first fifty cases to 141 min for the last fifty cases in a series of 200 cases (28). With our series now growing to over 1000 cases the operative times have reduced further to under 90 min. Ahlering et al. (23) have also reported a similar reduction in time with experience with a mean operative times of 184 min for their last

10 cases (in a series of 45) compared with the overall mean operative time of 207 min. In series comparing RALP with RRP performed by the same surgeon or at the same institution, no significant difference has been observed between operative times in this studies. (27,29).

Blood loss and transfusion

The transfusion rate after RALP has been reported to be 0–16.6% (16,18–21,23–28,30). Decreased intraoperative blood loss has been reported to be a hallmark advantage of laparoscopic prostatectomy (31). As most intraoperative blood loss originates from the venous sinuses, the tamponade effect created by pneumoperitoneum helps to diminish blood loss. In addition, early identification and precise ligation of vessels facilitates the limitation of blood loss (Figure 3). In many of the RALP series from the USA, there has been a 0% transfusion rate (20,23,24,27,30,32). Tewari et al. (29) report a significantly higher rate of transfusion after RRP (67%) compared with RALP (0%) in their single institution series comparing 100 RRP's performed by different surgeons and 200 RALP's performed by the same surgeon. Menon et al. (24) have also reported a higher rate of transfusion after LRP (2.5%) compared with RALP (0%). In a similar fashion, Farnhan et al. (33) demonstrated a decreased blood loss with RALP when compared with open surgery. Overall, the mean estimated blood loss in RALP series is 75–900 ml (16,18–21,23–25,27,28,30).

Length of hospital stay

Length of hospitalisation is an important component of convalescence after surgery and often considered a measure of patient well-being. The mean length of stay (LOS) in robotic series has been reported to be 1.08 to 5.5 days (16,18–28). In more recent RALP series of the USA, the mean LOS has been reported to be 1.08–1.5 days, decli-

ning with increasing experience (20–25,27,28). It would be expected that patients after LRP and RALP would have similar LOS because RALP is not less invasive but simply uses robotic assistance for performance of LRP. Ahlering et al. (27) reported shorter LOS in patients after RALP compared with RRP (25.9 vs. 52.8 h) performed by the same surgeon. Menon et al. (29) reported similar findings with mean LOS for RALP group being 1.2 days compared with 3.5 days for the RRP group. Thus, series comparing RALP with RRP from a single center or single surgeon have shown decreased LOS after RALP compared with RRP.

Erectile function

Erectile dysfunction after prostatectomy is a troublesome complication that occurs because of injury of the neurovascular bundle. Factors such as age, previous potency and unilateral or bilateral nerve preservation seem to affect postoperative return of erectile function (24).

In a series of patients submitted to RRP published by Walsh et al (34) an overall rate of potency defined by intercourse with or without the use of sildenafil has been reported to be 38% at 3 months, 54% at 6 months, 73% at 12 months and 86% at 18 months.

Whether there is an important difference between erectile function of patients submitted to either RRP, LRP or RALP is still not clear, but it has been proposed that RALP may prevent damage to the neurovascular bundle because dissection occurs in an antegrade fashion reducing traction on the nerve and better vision allows more precise dissection preventing inadvertent incision or incorporation into suture or clip. In a comparative series from a single center, Menon et al. (24) reported a potency rate of 29.4% (5/17) for RALP at mean follow-up of 1.5 months compared with 25% (3/12) in the LRP group at a mean follow-up of 6.5 months.

In a recent series of 565 RALP, Menon et al. (29) report 82% of preoperatively potent patients younger than age 60 had return to some sexual activity and 64% having sexual intercourse at 6 months. In patients older than 60, 75% had some return of sexual activity and 38% having intercourse at 6 months postoperative.

Furthermore, Menon et al. (35) had recently described a new technique of prostatic fascia preservation to avoid neurovascular bundle injury in patients submitted to RALP. A comparative study between conventional nerve sparing and prostatic fascia preservation has shown better potency rates in the second group (74% vs. 97% respectively) in 1 year of follow-up (35).

Although these data are still initial, these preliminary results suggest that LRP and RALP have similar

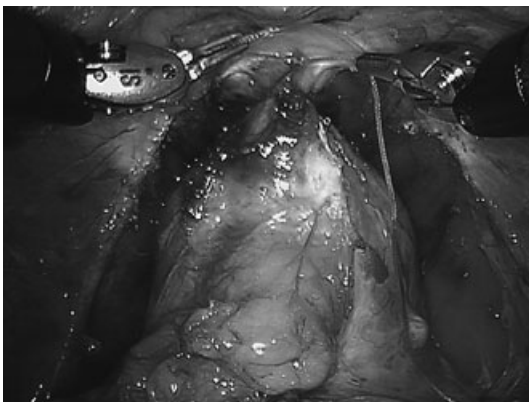


Figure 3 Prostate venous complex ligation

rates of postoperative potency compared with the best-reported rates after RRP.

Continence

In earlier series of RRP, the rate of incontinence based on patient-reported surveys was as high as 50% (36). Walsh et al. (34) reported continence (no pad usage in past 4 weeks) to be 54% at 3 months, 80% at 6 months, 93% at 12 months and 93% at 18 months. The pad free rate after RRP at 3 months postoperative has been reported to be between 50% and 76% (27,34,37).

It has been proposed that RALP can potentially result in better continence rates or earlier return of continence by improved preservation of urethral sphincter and urethral length. The theory is that better visualisation of the apex allows the surgeon to gently sweep away urethral sphincter muscular tissue from the anterior prostate and improved haemostasis prevents blood from obscuring the apex leading to inadvertent injury to the sphincter (38). Ahlering et al. (23) have reported continence rates of 33%, 63% and 81% at 1 week, 1 month and 3 months after RALP. In a comparative study, Ahlering et al. (27) found no significant difference in overall continence rates after RALP (76%) compared with RRP (75%) when performed by the same surgeon. However, Tewari et al. (29) have shown return to continence to be quicker in the RALP group with 50% being continent at 44 days compared with 160 days for RRP. In the landmark initial reports of RALP, Pasticier et al. (16) reported 80% of patient to be continent at 9 days postoperative and Binder (18) reported a 50% rate of continence at 1 month. Recently, Menon et al. (39) have reported a continence rate (no pads) of 96% at 3 months postoperatively. In our study of 200 patients, continence was described as the use of no pads daily and continence at 1, 3, 6, 9 and 12 months was 47%, 82%, 89%, 92% and 98% respectively (28).

Return of continence does appear to be earlier for RALP with a trend towards improved overall continence rates (98% for RALP vs. 95% in RRP in best reported results) even when including cases in the learning curve.

Oncologic

The primary goal of any sort of operative intervention for prostate cancer is oncologic cure. Men with high tumour stage, large tumour volume, multiple positive biopsies, high biopsy grade and high preoperative PSA are more likely to have a positive margin after surgery (40). Positive margin is a well-established independent risk factor for PSA recurrence (32). As such, any modifications of

the gold standard must provide for equivalent oncological outcomes to be considered viable options of treatment.

Most contemporary open RRP series report overall margin positive rates (MPR) of 12–25% (41). In literature review, Soloway et al. (40) reported positive margin rates after RRP to range from 0% to 77% with an overall average of 28% in reviewed RRP series. In this review, they also report MPR for T2a disease to be 0–38% with an average of 17%, 11–77% with an average of 36% for T2b and 25–59% with an average of 53% for T3 disease (40).

In RALP, the surgeon is made further devoid of tactile feedback as laparoscopic instruments are controlled by robotic arms without haptic feedback to the surgeon. With this, the fear of poorer oncological outcomes were heightened initially, but has subsided as most surgeons can overcome the lack of tactile feedback because of the improved 3D vision and magnification. The reported MPR after RALP in reported series ranges from 0% to 36.4% (16–21,23–28,30). When broken down by stage, MPR ranges from 0% to 16.7% for T2a, 0% to 33.3% for T2b, 0% to 20% for T2, 0% to 81.8% for T3a, 20% to 50% for T3b, 0% to 75% for combined T3 and 33.3% to 66.6% for T4 (16–21,23–28). This appears to be similar to those outcomes for RRP. In a comparative series, Ahlering et al. (27) in a single surgeon series reported a trend toward higher rate of positive surgical margins in open RRP group (20%) compared with the RALP group (16.7%) even though it did not reach statistical significance because of low sample size.

Interestingly Atug et al. (42) recently demonstrated that positive surgical margins tend to diminish with increased experience, suggesting a learning curve of approximately 30 cases for this procedure.

True oncological outcome can only be evaluated based on long-term survival data. As LRP and RALP are so new, these data are not available at this time. This prevents definitive comparison of RALP, RPP and LRP as regards superiority of oncological outcome.

Conclusion

Our review of the data for RALP shows a promising procedure in evolution. The limitations of robotic technology such as lack of haptic feedback seem to be outweighed by the advantages of improved visualisation and miniature instrumentation. While economic considerations are paramount the procedure is continuing to grow because of patient benefit and demand. The short-term data are growing quickly and are encouraging when compared with the

current gold standard in terms of functional and oncological outcomes. As robotic technology evolves and becomes more prevalent we expect to see continued innovation and improved surgical outcomes.

Conflict of interests

VP is a speaker for Pfizer and Intuitive.

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