Minimally Invasive Radical Prostatectomy

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The development of advanced laparoscopic techniques and robot-assisted technology has resulted in several new surgical approaches for treating organ-confined prostate cancer. Outcomes with these new or minimally invasive techniques should be assessed carefully to ensure that they are similar to or surpass patients' oncologic and functional outcomes after open radical prostatectomy. This article reviews the current published experience with minimally invasive approaches to increase awareness about viability. Several of the larger series of patients who have undergone laparoscopic (transperitoneal and extraperitoneal) or robot-assisted laparoscopic radical prostatectomies are discussed and evaluated critically. Comparisons to published data on open radical prostatectomy are included for completeness. The different minimally invasive techniques are described and contrasted in regard to prostate-specific antigen progression-free survival, surgical margin status, blood loss, transfusion rates, postoperative pain, length of hospitalization, duration of urinary catheterization, potency, continence, and complications. The relative costs of each method are provided. The coexistence of multiple surgical approaches should and can challenge surgeons who perform open and minimally invasive procedures to strive for a new standard of care above and beyond what is accepted today to minimize patient morbidity while maximizing functional and oncologic outcomes.

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LAP = laparoscopic radical prostatectomy; RAP = robot-assisted radical prostatectomy; RRP = radical retropubic prostatectomy; SV = seminal vesicle; TP = transperitoneal

Prostate cancer is the second most common cause of cancer death in men and is a major health concern worldwide. Surgical management of this disease has been an evolving process, beginning with Young's first radical perineal prostatectomy for carcinoma in 1904.[1] This technique was the standard of care for the next 40 years until 1945, when Millin pioneered a retropubic approach to the prostate.[2] Although both the perineal and the retropubic approaches were used for localized prostate cancer, they were associated with substantial morbidity. Prostate surgery could result in excessive blood loss, incontinence, impotence, and prolonged hospitalization and convalescence. The next major advancement decreased the morbidities associated with prostate surgery. Walsh et al[3] described a modified radical retropubic prostatectomy (RRP) in 1983 based on a better understanding of pelvic anatomy and hemostasis, which resulted in superior functional outcomes without compromising oncologic principles. These improvements in surgical technique and technology have resulted in not only enhanced oncologic outcomes but also decreased patient morbidity.

The evolution of prostate cancer treatment has now incorporated the principles of minimally invasive surgery. This trend has established a role for laparoscopic radical prostatectomy (LAP) in current urologic practice. Laparoscopic techniques have revolutionized the treatment of benign and malignant diseases in almost all surgical subspecialties. The goal of any new surgical procedure is improved results for the patient without compromise of disease control over time. It is currently being debated whether LAP meets these criteria and offers any unique benefit to the patient. The disadvantages of laparoscopic surgery include a steep learning curve, lengthy operative and set-up times, and complications not encountered with the equivalent open procedure. However, laparoscopic surgery has advantages, such as decreased postoperative pain and convalescence, possibly shorter hospitalization, and minimal disfigurement. When these factors are applied to prostatectomy, the current standard of care at experienced centers (>500 RRPs or radical perineal prostatectomies performed annually) must be considered. For example, published data from the Mayo Clinic in Rochester, Minn, revealed that 94.5% of patients were completely continent or used only 1 safety pad per day 1 year after RRP.[4] The complications encountered were myocardial infarction, pulmonary embolism, deep venous thrombosis, or bladder neck contracture in 0.7%, 0.6%, 1.4%, and 8.7% of patients, respectively. However, unpublished personal experience indicates that the rate of bladder neck contractures at this institution is actually much lower. Both margin-positive and lymph node–positive disease occurred in 12% of patients. The 10- and 15-year cause-specific survival rates were 90% and 83%, respectively.[4] In addition to excellent long-term oncologic and functional outcomes, most patients were discharged 48 hours after surgery, with oral pain medications, and few required a blood transfusion (currently, <5%). It is difficult to conceive of an operative

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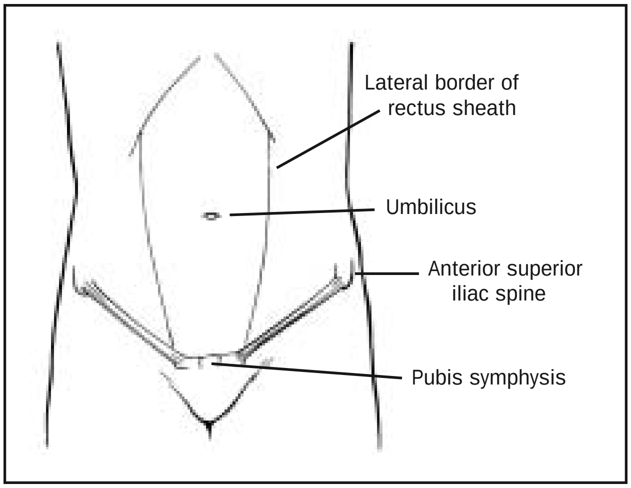

FIGURE 1. Abdominal landmarks for laparoscopic trocar placement.

technique that could improve on these end points. Proponents of LAP state that the laparoscopic approach is based on the same anatomical principles as the open approach but that additional structure preservation is realized through improved visualization, magnification, and hemostatic control. Because laparoscopic techniques are relatively new, long-term data comparisons with open operations are not possible, but several short-term series have been reported.

The first LAP was performed by Schuessler et al in 1991 and reported later with their cumulative experience in 1997.[5] Their mean operating time and the length of hospitalization were 9.4 hours and 7.3 days, respectively. Their results were based on a small patient population (9 patients), but they concluded that surgical cure and patient outcomes were equivalent to those with their open RRP experience. Since then, the development of intracorporeal suturing techniques and improved instrumentation has led to renewed interest in LAP. Two French groups (Guillonneau and Vallancien[6] and Abbou et al[7]) described a stepwise reproducible approach to LAP and reported results equivalent to those with traditional open procedures, which helped to revitalize the appeal of the technique. The recent innovations in robotic technology have specific applications for LAP. This article reviews the current laparoscopic and robot-assisted techniques and compares the relative efficacy, efficiency, and costs of these emerging minimally invasive procedures.

TECHNIQUE

Several different approaches to minimally invasive prostatectomy have been described, including the transperitoneal (TP), extraperitoneal, and robot-assisted method. The normal anatomical landmarks to consider during trocar placement while performing any of the minimally invasive techniques are shown in Figure 1. Generally, these procedures are accomplished using 4 to 6 trocars placed in a "W" or inverted "fan" configuration. Vesicourethral anastomosis is accomplished by either a continuous or an interrupted suturing technique, and the prostate is usually removed via an extension of the umbilical port site. Each approach has its own unique merits and drawbacks as described subsequently.

TP Approach

The procedure begins with peritoneal access and insufflation. A 5-trocar inverted fan port placement (Figure 2, left) is used, or conversely a W configuration (Figure 2, right) is used.[8] The patient is then placed in the Trendelenburg position, with the head tilted down approximately 45°. The initial dissection involves incision of the peritoneum overlying the rectovesical pouch and identification of the seminal vesicles (SVs) and vas deferens. The vas deferens is fulgurated with bipolar cautery, and the SVs are mobilized bilaterally. These structures are retracted anteriorly, Denonvilliers fascia is incised, and the plane between the prostate and rectum is developed carefully. (Some surgeons approach the initial dissection similarly to that used with the robot-assisted technique, described subsequently, in an effort to decrease bowel manipulation.) The bladder is then distended, using a transurethral bladder catheter, and the focus is on developing the space of Retzius. An inverted U-shaped peritoneotomy is made dividing the urachus, and the avascular plane is developed along the sides of the bladder. The superficial dorsal vein is coagulated and transected. The prostate is placed on traction during incision of the endopelvic fascia. Once the apex of the prostate is visualized, the transurethral bladder catheter is replaced by a urethral sound, which allows some tactile discrimination. The dorsal venous complex overlying the prostate is then ligated with 1 to 2 sutures; caution must be used to ensure that the sutures are placed distal to the apex between the urethra and deep dorsal venous complex. The bladder is then retracted caudally, and the bladder neck is transected circumferentially. The anterior layer of Denonvilliers fascia is incised, and the SVs and vas deferens are delivered into the field. For nerve preservation, careful antegrade mobilization of the nerve bundles from the lateral prostatic pedicles is achieved, generally using hemostat clips rather than cautery. The urethra and deep dorsal vein are placed on traction and transected just distal to the apex of the prostate. The bladder neck mucosa is everted, and the vesicourethral anastomosis is performed. Some surgeons choose to use an interrupted anastomosis, whereas others use a running anastomosis to decrease the time involved with multiple knot tying.[9-11] A transurethral catheter is placed into the bladder before the final suture is secured.

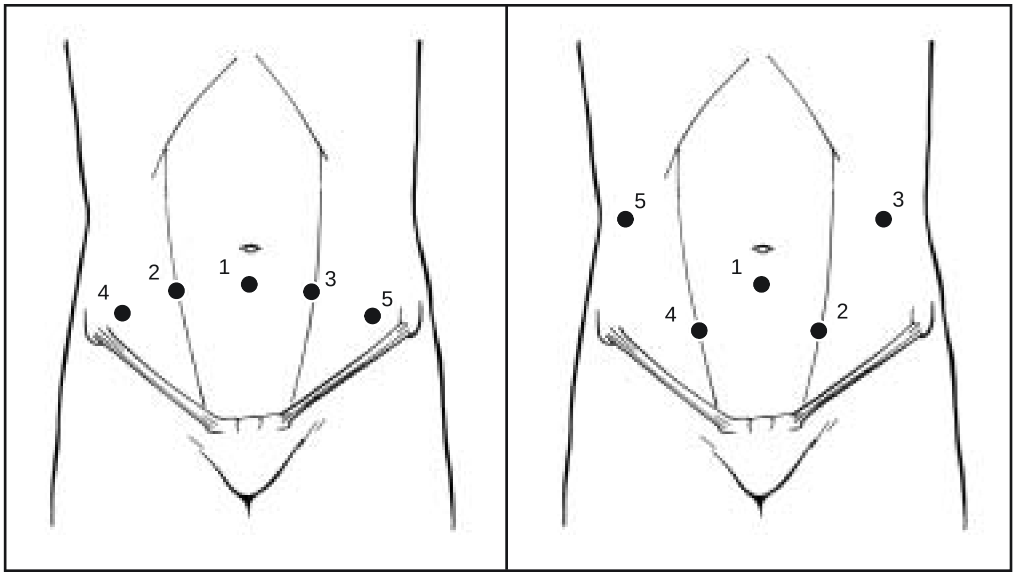

FIGURE 2. Left, Trocar placement for inverted "fan" transperitoneal approach. 1 = 10- or 12-mm trocar at the inferior umbilical crease; 2 = 5-mm trocar in lateral rectus border, 2 finger breadths below umbilicus; 3 = 12-mm trocar in lateral rectus border, 2 finger breadths below umbilicus; 4 = 5- or 10-mm trocar, 2 finger breadths medial to anterior superior iliac spine; 5 = 5-mm trocar, 2 finger breadths medial to anterior superior iliac spine. Right, Trocar placement for "W" configuration transperitoneal approach. 1 = 12-mm trocar at the inferior umbilical crease; 2 = 10- or 12-mm trocar in left lateral rectus sheath, 2 to 4 cm below umbilicus; 3 = 5-mm trocar in left lateral abdomen at or just above level of umbilicus; 4 = 10- or 12-mm trocar in right lateral rectus sheath, 2 to 4 cm below umbilicus; 5 = 5-mm trocar in right lateral abdomen at or just above level of umbilicus.

The mobilized prostate (specimen) is then delivered through an extension of the umbilical port site, drains are placed, and port sites are closed.

The transperitoneal approach allows maximum mobility of the bladder, which aids in creating a tension-free vesicourethral anastomosis. The intra-abdominal cavity provides a large working space and allows easy maneuverability of the instruments. These advantages have made the transperitoneal approach the most common minimally invasive approach to prostatectomy. However, the direct intra-abdominal communication is associated with some difficulties, including the need for bowel manipulation, an ileus, intraperitoneal communication of blood and urine, and the potential for damage to organs that would otherwise not be exposed. These concerns led to refinement and development of an extraperitoneal approach.

Extraperitoneal Approach

The first extraperitoneal laparoscopic approach (Figure 3) was described in 1997 by Raboy et al.[12] With this approach, the initial step is to create the extraperitoneal space. An infraumbilical incision is made, staying superficial to the peritoneum, and the retroperitoneal space is created using blunt finger dissection or via a 12-mm trocar balloon.[12] With the modification by Stolzenburg and Truss,[13] the trocar is placed at the right anterior iliac spine, rather than near the pubic symphysis, and the other right-sided trocar is placed near or at the lateral margin of the rectus muscle. After the peritoneum is completely free and the space developed, the endopelvic fascia is incised, exposing the apex of the prostate. The superficial venous complex is fulgurated with bipolar cautery. The dorsal venous complex is then doubly ligated but not divided. Blunt dissection at the apex identifies the neurovascular bundles, which will be dealt with later. The bladder neck is first divided anteriorly, and the transurethral catheter is manipulated into the retropubic space for the remainder of the bladder neck dissection. The anterior layer of Denonvilliers fascia is perforated in the midline, allowing transection of the vas deferens and mobilization of the SVs. To develop the plane between the rectum and the prostate, the distal layer of Denonvilliers fascia is perforated until the prostatic apex is visualized. The nerves are preserved if appropriate, and the lateral prostatic pedicles are taken down in a stepwise fashion, completely mobilizing the prostate except for the urethral and dorsal venous attachments. The dorsal venous complex is transected, and additional hemostasis is addressed as necessary. The urethra is carefully transected to preserve the neurovascular bundles and external sphincter. The mobilized prostate (specimen) is removed before vesico-

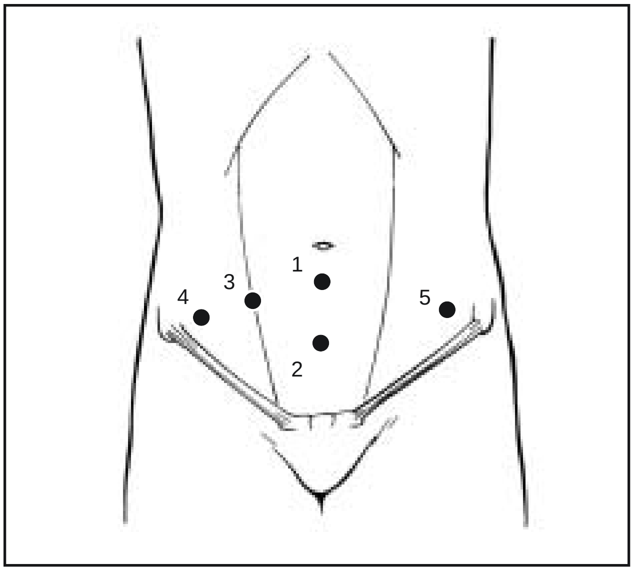

FIGURE 3. Trocar placement for extraperitoneal approach. 1 = 10- or 12-mm Hasson trocar at the inferior umbilical crease; 2 = 5-mm trocar at the midline, 3 to 5 cm below umbilicus; 3 = 5-mm trocar in right lateral rectus border, 2 cm below umbilicus; 4 = 5-mm trocar, 2 finger breadths medial to right anterior superior iliac spine; 5 = 10- or 12-mm trocar, 2 finger breadths medial to left anterior superior iliac spine.

urethral anastomosis to maximize working space in the retroperitoneum. Alternatively, the procedure has been described starting at the prostatic apex and working caudally toward the bladder neck.[12]

The extraperitoneal method closely resembles the open RRP. Because no bowel is manipulated, the chance of an ileus or injury is decreased. Less Trendelenburg positioning is needed since the bowel does not need to be retracted, which may result in improved anesthetic and cardiovascular factors. Intraperitoneal contamination is not a concern, and the confined retroperitoneal space may aid in venous tamponade. The main limitation is the restricted working space, but with experience this does not seem to be an important drawback.

The final approach to prostatectomy can be either technique previously described but relies on robotic assistance.

Robot-Assisted Approach

Robotic technology has advanced to the point of being able to assist in and perform surgery. The development of "wristed" endoscopic instrumentation, telemanipulation, and 3-dimensional visualization have culminated in 2 widely available master-slave robotic systems: the da Vinci Robotic Surgical System and the ZEUS Robotic Surgical System (Intuitive Surgical, Inc, Sunnyvale, Calif). The data and experience with the da Vinci system have been reported more extensively.

The da Vinci system requires the surgeon to sit at a console that provides a 3-dimensional representation of the operative field. The surgeon's wrist movements are translated in real time to the slave apparatus that actually stabilizes and controls 2 detachable surgical instruments as well as the camera. The endowrist (Intuitive Surgical, Inc) allows for 6 degrees of freedom to maximize surgical dexterity, and movements can be filtered and scaled to prevent inadvertent tremor and to increase precision. This system allows the surgeon to operate in a controlled and comfortable position to reduce strain and fatigue. Both the transperitoneal and the extraperitoneal approach (Figure 4) have been described in conjunction with the da Vinci system.

The ZEUS system is similar in that the surgeon is seated at a console with standard 2-dimensional representation of the operative field; however, instead of "wristed" controls, 2 handles are used for operation. The camera is attached to a voice-activated device (AESOP, Intuitive Surgical, Inc), and the 2 robotic arms are attached to the operating table. Standard instrumentation only allows 4 degrees of freedom compared with 6 degrees of freedom with the da Vinci system. Both systems require 1 or 2 assistants at the operating table to handle instrument changes and provide traction as needed. The ZEUS system is no longer supported by the manufacturer.

Robotic systems offer improved visualization and depth perception over other laparoscopic techniques. The additional degrees of freedom of the instruments make suturing easier, and operator comfort is maximized. However, both systems are expensive and bulky, have a small variety of available instruments, remove all aspects of tactile discrimination, and require expensive maintenance and troubleshooting. The availability of minimally invasive techniques and their application require a careful review of outcomes and complications.

OUTCOMES

Short-term follow-up or inadequate experience precludes an in-depth comparison of minimally invasive techniques to open radical prostatectomy, but trends can be identified. Assessment of outcomes regarding subjective variables such as continence and potency is problematic for all surgical procedures for prostate cancer because of the variability in data reporting and recording instruments. Assessment of early outcomes with LAP is further complicated because procedures performed during the operator-dependent learning curve are included in the data. Nonetheless, the high standards of open surgery must at least be sustained and preferably surpassed before minimally invasive prostatectomy can be considered a viable option in the surgical armamentarium.

Cancer Progression

Data on cancer-specific and metastasis-free survival after LAP have not been reported, and the currently available information is for short-term follow-up with fewer patients than with open prostatectomy. Clinical and pathologic stage, patient age, and other factors are inherent to the consideration of cancer control. Relevant factors in cohorts of at least 20 patients who have undergone minimally invasive techniques are listed in Tables 1 and 2. Most oncologic data for laparoscopic techniques involve the description of biochemical (prostate-specific antigen [PSA])-free survival. Guillonneau et al[22] evaluated 1000 patients who had undergone LAP and found that the pathologic stage–specific progression-free survival was 91.8%, 88%, 77%, 44%, and 50% for pT2a, pT2b, pT3a, pT3b, and pT1-3N1, respectively, for a median follow-up of 12 months. The overall actuarial biochemical progression–free survival rate at 3 years was 90.5%. Hoznek et al[10] reported a PSA progression–free rate of 89.6%, with a mean follow-up of 11 months. Similarly, Rassweiler et al[29] reported a PSA progression–free rate of 95%, with a median follow-up of 12 months. For patients with organ-confined prostate cancer, the 5-year PSA progression–free survival for open prostatectomy has been reported to be 91% to 95%.[30-32] The test of time will indicate if minimally invasive techniques can maintain biochemical progression–free rates equivalent to those of open procedures and will also allow assessment of cancer-specific and metastasis-free survival.

Margin Status

Generally, a surgical margin is considered positive if tumor cells reach the "inked" boundaries of the prostate specimen on pathologic examination. The risk of cancer recurrence increases significantly with positive surgical margins independent of pathologic grade, PSA, and DNA ploidy for organ-confined disease.[33-39] Several series have stressed the importance of surgical margin status in the development of postoperative multivariate models to determine patient prognosis. At our institution, a simple and accurate method to predict biochemical progression after radical prostatectomy was devised using the weighted sum of the pathologic Gleason score, preoperative PSA, SV status, and margin status (ie, the GPSM score). The 5-year progression-free survival was 94% for scores lower than 5 and only 32% for scores greater than 12, highlighting the importance of margin status.[37] The impact of surgical margin status is further illustrated by the study of 842 patients with pT3a/bN0M0 (patients with extraprostatic extension) disease who had a 5-year survival free of clinical recurrence of 65% vs 76% for patients with and without positive margins.[39] As such, margin status is an important prognostic indicator after radical prostatectomy performed by either laparoscopic or open surgical techniques. Most contemporary open radical prostatectomy series report a positive margin rate between 12% and 25% (the reported positive margin rate from our institution is 12%).[4,34] Comparatively, the rate of positive margins for larger LAP series is between 6% and 30% (Table 2). Guillonneau et al[22] reported an overall rate of positive margins of 19% with the following site distribution: 50% apical, 30% posterior lateral, and 20% at the base of the prostate. The site of the positive surgical margin has been determined to impact the biochemical recurrence in organ-confined prostate cancer after radical prostatectomy. Blute et al[36] examined 2334 patients after RRP with organ-confined disease. The site of the positive margins was as follows: 58% at the apex, 19% at the prostate base, 2.5% at the anterior prostate, and 40% at the posterior prostate. The 5-year survival-free progression of biochemical failure was 79%, 78%, and 56% for the positive prostate margins at the apex, anterior/posterior, and base, respectively. This clearly emphasizes the importance of the anatomical site of the positive margin and must be considered when critically evaluating minimally invasive techniques. Salomon et al[18] examined the medical records of patients with organ-con-

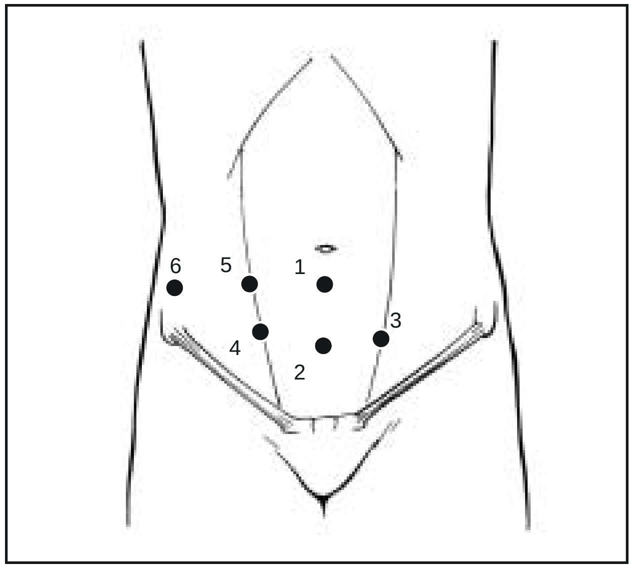

FIGURE 4. Trocar placement for extraperitoneal robotic approach. 1 = 12-mm trocar, 1 finger breadth inferior to the umbilicus (for the camera); 2 = 5-mm trocar, 2 finger breadths above pubic symphysis in the midline; 3 = laparoscopic robotic port, 8-mm trocar along the left lateral rectus border, 1 hand breadth inferior to trocar No. 1; 4 = laparoscopic robotic port, 8-mm trocar along the right lateral rectus border, 1 hand breadth inferior to trocar No. 1; 5 = 5-mm trocar along the right lateral rectus border, 1 to 2 cm inferior to trocar No. 1; 6 = 12-mm trocar, 2 finger breadths medial to the anterior superior iliac spine. The transperitoneal technique differs in that trocars No. 3 and No. 4 are 4 cm cranial to their position depicted here.

TABLE 1. **Relevant Factors in Patient Cohorts Who Have Undergone Minimally Invasive Techniques***

Reference	Approach	No. of patients (nerve sparing†)	Mean age (y) (range)	Mean preoperative PSA (ng/dL) (range)	Mean Gleason score (range)	Clinical cancer stage			
						cT1a or cT1b	cT1c	cT2	cT3
Gill & Zippe,[9] 2001	TP-LAP	40 (9)	65.4 (57.0-71.0)	6.9 (4.2-12.5)	6.1 (5.0-7.0)		28‡	12	
Hoznek et al,[10] 2001	TP-LAP	134§	64.8 (47.0-77.0)	11.6 (2.0-50.0)	5.9 (3.0-8.0)	6	85	43	
Guillonneau et al,[14] 2001	TP-LAP	350	64 (49-77)	10.8 (1.7-55.0)	5.8 (2.0-9.0)	3	219	128	
Olsson et al,[15] 2001	TP-LAP	228	65.2 (46.9-77.0)	NR	NR	NR			
Dahl et al,[16] 2002	TP-LAP	70	60.8 (40.0-76.0)	6.6 (1.5-20.7)	NR	NR			
Eden et al,[17] 2002	TP-LAP	100 (58)	62.2 (52.0-72.0)	8 (2-32)	6 (4-8)	3	57	37	3
Salomon et al,[18] 2002	TP-LAP	137	64.1	11.6	5.7	NR			
Salomon et al,[19] 2003	TP-LAP	169	63.8	8.9	NR	8	118	43	
Rassweiler et al,[20,21] 2003	TP-LAP	450	65	11.8	6	NR			
Guillonneau et al,[22] 2003	TP-LAP	1000	63 (44-77)	10.0 (1.5-55.0)	NR	9	660	331	
Hoznek et al,[23] 2003	EP-LAP	20 (16)	67.0 (52.5-75.3)	11.7	6.3 (2.0-8.0)		14	6	
Stolzenburg et al,[24] 2003	EP-LAP	70 (9)	63.4 (49.0-76.0)	12.5 (1.4-50.7)	4-8	NR			
Roumeguere et al,[25] 2003	EP-LAP	85 (26)	62.5	8.6	5.4	NR			
Menon et al,[26] 2002	RAP	40	60.7	5.7	NR		28	12	
Bentas et al,[27] 2003	RAP	40	61.3 (45.0-72.0)	11.5 (0.5-53.0)	5.8 (2.0-9.0)	3	16	21	
Menon et al,[28] 2003	RAP	200	59.9 (42.0-76.0)	6.4 (0.6-41.0)	NR		80∥	81∥	

*EP = extraperitoneal; LAP = laparoscopic radical prostatectomy; NR = not reported; PSA = prostate-specific antigen; RAP = robot-assisted radical prostatectomy; TP = transperitoneal.
†Data reflect both bilateral and unilateral nerve-sparing procedures.
‡Although 200 patients underwent surgery, complete data were available for only 134 patients.
§No distinction was made between cT1a, cT1b, or cT1c.
∥Cohort was reported as 200 patients, but clinical stage was reported for only 161 patients.

fined disease at their institution, compared RRP, radical perineal prostatectomy, and LAP cohorts, and found that 19%, 14%, and 22% of the surgical margins, respectively, were positive.

Although margin positivity is an important prognostic variable, it is unknown how the role of margin status has been impacted by patient selection, choice of operative technique, surgeon experience, pathologic handling, or stage migration. In fact, for experienced surgeons, margin positivity may be a reflection of tumor biology rather than technical skill. Therefore, the use of margin positivity as a surrogate of cancer control between laparoscopic and open surgery may be an inaccurate factor for comparison. The range of reported margin status for LAP series suggests that a positive margin is highly dependent on the skill and experience of the surgeon, as in open RRP series. Initial concerns regarding high rates of positive surgical margins with minimally invasive approaches have been somewhat diminished with refinement in technique and experience. However, the potential for positive margins due to the lack of tactile discrimination at the posterior prostate, where the risk of biochemical failure is greatest, remains a concern. The challenge of identifying the "correct" rectoprostatic plane, discerning the bladder from the prostate at the bladder neck, or isolating the neurovascular bundles from the lateral prostatic pedicles all are areas of potential positive margins. These may represent challenges early in the LAP surgeon's experience but must be contemplated in selecting a particular surgical approach to prostate cancer. The institutional differences between pathologic processing and reporting of surgical specimens must also be considered when comparing open prostatectomy series to minimally invasive series. Additional experience is required to determine whether margin positivity can be truly reduced with minimally invasive approaches.

Transfusion Rates

The greatest advantages of minimally invasive approaches to the patient are lower operative blood loss, lower transfusion rates, and improved postoperative pain control. The

TABLE 2. **Surgical Outcomes in Patient Cohorts Who Have Undergone Minimally Invasive Techniques***

Reference	Approach	Open conversion rate (%)	Mean operation time (h) (range)	Mean blood loss (mL) (range)	Transfusion rate (%)	Positive margin rate (%)	Mean hospitalization (d) (range)	Clinical cancer stage			
								pT2	pT3	pT4	N^+
Gill & Zippe,[9] 2001	TP-LAP	2.5	5.6 (3.5-10.0)	340 (75-1000)	2.5	23	1.6 (1.0-6.0)	NR			
Hoznek et al,[10] 2001	TP-LAP	0	4†	NR	3	25	6.2	101	33		
Guillonneau et al,[14] 2001	TP-LAP	2	3.6 (1.8-8.3)	354 (50-1500)	5.7	15.4	6 (2-33)	291	59		
Olsson et al,[15] 2001	TP-LAP	NR	NR	NR	3	24.6	NR	NR			
Dahl et al,[16] 2001	TP-LAP	1.4	4.6 (2.8-8.3)	449 (50-2750)	5.7	11.4	2.5 (1.0-6.0)	65	5		
Eden et al,[17] 2002	TP-LAP	1	4.1 (2.4-10.0)	313 (50-1300)	3	16	4.2 (3.0-13.0)	NR			
Salomon et al,[18] 2002	TP-LAP	NR	4.75 (3.00-10.70)	NR	2.9	22	7.4	104	33		4
Salomon et al,[19] 2003	TP-LAP	NR	NR	NR	NR	18.9	NR	169			1
Rassweiler et al,[20,21] 2003	TP-LAP	1.6	4.2	NR	24.8	18.7	NR	273	158	19	4
Guillonneau et al,[22] 2003	TP-LAP	1.2	3.4 (1.5-8.3)	380	4.9	19	NR	NR			
Hoznek et al,[23] 2003	EP-LAP	0	2.8	442.1	10	25	6.4 (4.0-14.0)	8	9	3	
Stolzenburg et al,[24] 2003	EP-LAP	0	2.6	350 (100-850)	1.4	21.4	NR	33	34	3	
Roumeguere et al,[25] 2003	EP-LAP	NR	4.8	522	NR	7.8‡	NR	50	35		2
Menon et al,[26] 2002	RAP	0	4.6	256	0	17.5	NR	33	7		
Bentas et al,[27] 2003	RAP	5	9.3	570	32.5	30	17.1	25	15		
Menon et al,[28] 2003	RAP	NR	2.7	153	0	6	1.2	165§	25§		

*EP = extraperitoneal; LAP = laparoscopic radical prostatectomy; N^+ = lymph node–positive disease; NR = not reported; RAP = robot-assisted radical prostatectomy; TP = transperitoneal.
†Reported as a median value after the first 20 patients for a nerve-sparing TP-LAP.
‡Reported only for organ-confined disease (pT1-pT2).
§Cohort was reported as 200 patients, but pathologic stage was reported for only 190 patients.

initial description of the LAP technique by Schuessler et al[5] showed that the mean estimated blood loss was 583 mL with no transfusions required. Later clinical experience has supported this early observation. At the Montsouris Institute in France, the transfusion rate and estimated blood loss have improved with experience. The first 50 patients had a transfusion rate of 18%, whereas the last 250 patients had a rate of 2.8%.[14] Rassweiler et al[20] reported a transfusion rate of 38.6% for the first 150 patients who underwent LAP and an 11.3% rate for the most recent patients. One of the technical improvements to account for this difference is the late division of the dorsal venous complex, which was partly responsible for the early increased blood loss.[29] Others have noted that the positive pressure used in laparoscopic techniques has been sufficient to decrease the bleeding from venous sources during the operation. Some open RRP series have reported average estimated patient blood losses as high as 1500 mL.[40] However, at experienced centers where more than 500 open RRPs are performed annually (at our institution >900 open RRPs are performed annually), this observation has not been supported. Based on our institutional experience and on most available data, estimated blood loss and transfusion rates seem to be comparable between open and laparoscopic techniques, with perhaps a slight advantage for the more recent laparoscopic experience. As expertise with minimally invasive techniques continues to develop, additional hemostatic benefits may be realized.

Postoperative Pain

Several LAP series report improvements in postoperative pain. Guillonneau and Vallencien[41] used a visual analog pain scale (1-10) to evaluate postoperative pain in 35 patients after transperitoneal (TP)-LAP. A score of 1 to 2 was reported in 80% of patients (n=28) on the first postoperative day. Of this group, 75% were discharged home before the fourth postoperative day. Tewari et al[42] compared patient-reported pain after robot-assisted radical prostatectomy (RAP) and RRP and noted that those who underwent RAP had less pain. Most care providers agree that use of parenteral analgesics is rarely necessary for patients with low pain scores. Other centers have reported less analgesic use after LAP compared with open surgery.[15,43] Both open and laparoscopic procedures are associated with early discontinuation of intravenous fluids, rapid resumption of diet, and early ambulation. To compare patients who had undergone RRP with those who had undergone LAP, Hara et al[44] used quality-of-life questionnaires 6 months after surgery and found no significant difference between the 2 groups. However, long-term disability has been defined poorly for both open and laparoscopic procedures, and further evaluation is needed. It is unclear whether a low midline muscle-sparing incision for an open procedure is more traumatic to the abdominal wall musculature than are multiple incisions for trocars with a laparoscopic procedure and whether this affects the patient's recovery or convalescence.

Length of Hospitalization

Length of hospitalization is often considered a measure of patient well-being after surgery. Considering cultural and economic differences between US and European health care systems, length of hospitalization is an inaccurate assessment of well-being. In Europe, the length of hospitalization is determined essentially by need for urinary catheterization rather than medical necessity. Therefore, the introduction of LAP has substantially decreased the mean length of hospitalization compared with European series of RRP and radical perineal prostatectomy. Guillonneau et al[14] reported a mean length of hospitalization of 6.2 days in their series of 350 consecutive patients who underwent LAP. In comparing the early vs late experience of Abbou et al,[7] length of hospitalization decreased from 7.8 to 6 days. For LAP performed in the United States, Gill and Zippe[9] reported a mean length of hospitalization of 1.6 days. The Vattikuti Urology Institute in Michigan reported a mean hospital stay of only 36 hours for their patients who underwent RAP.[45] In their series of 70 patients, Dahl et al[16] reported that their patients were discharged home a mean of 2.5 days after LAP. At our institution, where more than 900 open RRPs are performed annually, the mean length of hospitalization is 24 to 48 hours postoperatively. This suggests that length of hospitalization after minimally invasive and open procedures is similar.

Duration of Catheterization

The required time of urinary catheterization has decreased substantially with minimally invasive techniques. Nadu et al[46] prospectively evaluated early catheter removal among 113 consecutive patients after TP-LAP. Findings on cystograms obtained 2 to 4 days postoperatively were used to determine catheter removal. If a leak was noted, the catheter was left in place for an additional 6 days, followed by another cystogram. In 84.9% of patients, the catheter was removed after the first cystogram, and after 7 months of follow-up, no adverse consequences (vesical neck contracture, urinoma, infection, or abscess) were reported.[46] Menon et al[45] reported a mean duration of catheterization of 10.7 days for patients who had undergone RAP compared with 13.7 days for those who had undergone RRP. Early catheter removal is attributed to better visualization of the vesicourethral anastomosis. Some minimally invasive surgeons do not obtain a cystogram to ensure healing, but most surgeons who remove the catheter early continue to do so. From a quality-of-life standpoint, early catheter removal appears to provide an advantage for patients who undergo laparoscopic procedures.

Patients who are unable to void after early catheter removal require further intervention. Data addressing this topic are limited, but the potential risk to the "new" urethrovesical anastomosis and inconvenience to the patient must be measured. However, based on reports of success in several contemporary open prostatectomy series, the catheter has been removed early, and results are equivalent.[47] The optimal duration for catheterization after prostatectomy has yet to be determined, but early removal is an appealing factor for patients.

Potency

Since the primary goal of most minimally invasive series has been oncologic control, data regarding functional outcomes are limited. No consensus has been achieved regarding the ideal tools or methods for determining continence or potency. Most experts would agree that self-administered, validated quality-of-life questionnaires provide the most objective measurement, but inconsistency among these instruments has limited their global applicability. Functional outcomes reported in the literature are listed in Table 3. Guillonneau et al[14] queried 42 consecutive patients about potency 6 months after LAP; the response rate was 90% (38/42 patients). Patients who reported preoperative impotence (n=16) were excluded. Of the remaining 22 responders, 7 (32%) had erections sufficient for intercourse, and 6 (27%) had partial erections, for an overall erection rate of 59%. Hoznek et al[10] described a cohort of 134 patients and found an 83% sexual activity rate postoperatively. At 1-month follow-up, the erection rate sufficient for intercourse was 20%, 28%, and 46% for non–nerve-sparing, unilateral nerve-sparing, and bilateral nerve-sparing LAP, respectively. The 20% incidence of erections associated with a non–nerve-sparing technique suggests either a remarkable effect of the laparoscopic approach or more likely a disadvantage of using questionnaires to assess outcome. Depending on the minimally invasive approach, length of follow-up, and type of questionnaire, the

TABLE 3. **Lifestyle Outcomes in Patient Cohorts Who Have Undergone Minimally Invasive Techniques***

Reference	Approach	Mean catheter duration (d)	Mean follow-up (mo)/ No. of patients	Continence rate† (%)	Potency rate† (%)	Progression-free survival‡ (%)
Hoznek et al,[10] 2001	TP-LAP	4.8	12/29	86.2	56.0	89.6
Guillonneau et al,[14,22] 2001, 2003	TP-LAP	5.8	12/131	85.5	59.0§	90.5
Olsson et al,[15] 2001	TP-LAP	4	12/37	78.3	NR	NR
Eden et al,[17] 2002	TP-LAP	NR	9.8/NR	90.0	62.0	NR
Salomon et al,[18] 2002	TP-LAP	6.8	NR	NR	NR	84.1∥
Rassweiler et al,[20,21] 2003	TP-LAP	NR	18/150	94.7	NR	NR
Stolzenburg et al,[24] 2003	EP-LAP	8.2	3/50	72.0	33.3	NR
Roumeguere et al,[25] 2003	EP-LAP	NR	12/52	80.7	65.3	NR
Bentas et al,[27] 2003	RAP	16.7	11-23¶/38	68.0	NR	NR
Menon et al,[28] 2003	RAP	7	NR	NR	NR	92.0#
Salomon et al,[48] 2002	TP-LAP	NR	12/100	90.0	58.8	NR

*EP = extraperitoneal; LAP = laparoscopic radical prostatectomy; NR = not reported; RAP = robot-assisted radical prostatectomy; TP = transperitoneal.
†Based on follow-up data; continence is defined as no pad required; potency is with or without medication.
‡Overall progression-free survival at 3 years.
§Data reported at 6-month follow-up for 22 patients.
∥Actuarial 3-year recurrence-free survival was 90.4% for patients with organ-confined tumors.
¶Reported as "11 to 23 months after surgery."
#Reported as undetectable prostate-specific antigen level at 6 months.

potency rate seems to be between 33% and 66%. The results are promising with LAP but could be improved based on the outcomes with open RRPs performed at experienced centers. However, LAP series tend to incorporate early procedures during the learning curve of the technique, and thus outcomes may improve over time with greater surgical experience. Nerve-sparing procedures should continue to be performed in cases in which oncologic control is not compromised.

Continence

The issue of continence is a central concern among most patients, and thus analyzing the data objectively is important. Data on continence after minimally invasive procedures are highlighted in Table 3. The lack of consistency in terminology makes direct comparisons between different studies complex. Guillonneau et al[14] assessed functional outcomes in their first 133 patients at 12 months of follow-up using the International Continence Society self-administered questionnaire; the overall response rate was 98.5% (131/133 patients). The true continence rate, no pads or protection during the day or at night, at 1 year was 85.5% (112 patients), 10.7% of patients (n=14) wore 1 pad per 24-hour period, and 3.8% of patients (n=5) complained of severe incontinence. Olsson et al[15] prospectively evaluated 115 patients with the International Continence Society questionnaire at 1, 3, 6, and 12 months after TP-LAP, and the response rates were 88%, 67%, 44%, and 32%, respectively. If the patient never leaked urine and never wore a pad even for protection postoperatively, this was defined as *perfect continence*. Rates of perfect continence were 9.9%, 28.6%, 57.4%, and 56.8% for responders at 1, 3, 6, and 12 months, respectively. The no pad rate for the 1-, 3-, 6-, and 12-month follow-up interval was 18.8%, 58.4%, 68.9%, and 78.4%, respectively. Additionally, no patient reported wearing more than 1 pad per day after 6 months postoperatively. A clear limitation of this study is the unknown continence status of the nonresponders because only 32% of patients responded at 1 year. Salomon et al[48] reported the continence rate for 100 consecutive patients who underwent LAP after 1 year and found that 90% had diurnal continence, 6% used 1 pad per day, and 4% used more than 1 pad per day. However, Egawa et al[49] found that continence rates after LAP were 2.9%, 29.4%, 46.9%, 56.0%, and 60.0% for patients at 1, 3, 6, 9, and 12 months after TP-LAP. Comparatively, continence rates for the RRP cohort were 22.4% at 1 month, 63.3% at 3 months, 84.1% at 6 months, 92.9% at 9 months, and 92.9% at 1 year postoperatively. These inferior continence rates could be due to the inclusion of patients during the learning curve of LAP or a lack of laparoscopic expertise; either way, these results suggest the superiority of open procedures at that institution.[49] Most data tend to equilibrate continence rates between open and minimally invasive approaches, but as more data are accumulated, trends may become clearer.

TABLE 4. **Comparison of Complications in Patient Cohorts (>100) Who Have Undergone Minimally Invasive Techniques***

	Hoznek et al,[10] 2001	Rassweiler et al,[20,21] 2003	Salomon et al,[18] 2002	Guillonneau et al,[50] 2002	Menon et al,[28] 2003
Approach	TP-LAP	TP-LAP	TP-LAP	TP-LAP	RAP
No. of patients	134	450	139	567	200
Complications	16 (11.9)	68 (15.1)	25 (18)	105† (17.1)	8 (4)
Intraoperative					
Rectal injury	2 (12.5)	6 (8.8)	2 (8)	8 (7.4)	
Rectal fistula		7 (10.3)			
Bowel injury				3 (2.9)	
Ureteral injury			1 (4)	3 (2.9)	
Bladder injury				9 (8.6)	
Epigastric injury				3 (2.9)	
Postoperative					
Lymphorrhea	4 (25)		4 (16)	1 (0.9)	
Urinary fistula	1 (6.3)		5 (20)		
Urethral anastomosis leak	4 (25)			57 (54.3)	
Abscess	1 (6.3)			1 (0.9)	
Ileus		15 (22)	4 (16)	6 (5.7)	3 (37.5)
Hematoma		18 (26.5)	1 (4)	5 (4.8)	
Delayed bleeding					1 (12.5)
Stricture		16 (23.5)			
Obstructive anuria				1 (0.9)	
Wound dehiscence				4 (3.8)	
Hernia at port site					3 (37.5)
Medical					
Parietal complication			1 (4)		
Deep venous thrombosis			1 (4)	2 (1.9)	1 (12.5)
Phlebitis	1 (6.3)				
Pneumopathies	2 (12.5)		2 (8)		
Transient ischemic attack	1 (6.3)		1 (4)		
Pulmonary embolism		2 (2.9)	1 (4)		
Pyelonephritis			1 (4)		
Gastrointestinal ulcers			1 (4)		
Other		4 (5.9)		2 (1.9)	

*Values are number (percentage). RAP = robot-assisted radical prostatectomy; TP-LAP = transperitoneal laparoscopic radical prostatectomy.

†There were 105 complications reported for 97 patients in a cohort of 567 patients.

Complications

Unique complications of the minimally invasive approach and complications specific to prostatectomy have been reported; however, the overall incidence seems to decrease with experience. The most common complications in the largest reported laparoscopic series are listed in Table 4. Guillonneau et al[50] reported an overall complication rate of 17.1% or 105 complications in 97 of 567 patients. Hoznek et al[10] reported a 22.5% complication rate among the first 40 LAP cases but only a 3.2% complication rate in the next 94 LAP cases. Similarly, Guillonneau et al[50] had to convert 7 LAP to open procedures in their first 70 patients but none in their next 497 patients. Rassweiler et al[29] also reported a high (8.1%) conversion rate among their first 60 patients but only a 1.7% conversion rate in their last 60 patients. Complications requiring open conversion included hemorrhage, rectal injuries, vessel trauma, or difficult dissections. The most common complication reported was urinary fistula or urine leak at the anastomosis, which may reflect early experience and the fact that most practitioners obtained a cystogram before removing the urinary catheter early. Prolonged ileus due to bowel manipulation accounted for 22% of the complications experienced by Rassweiler et al,[29] but this occurred in only 3.3% of the 450 patients who underwent TP-LAP. This complication rarely occurs with the extraperitoneal approach. Other unique complications of the minimally invasive procedure are inferior epigastric injury and hernia at the port site secondary to trocar placement. These were reported in less than 2% of cases at centers that have experience with LAP.[18,20,29,42,50] The incidence of deep venous thrombosis has been reported to be extremely low with LAP, 0.4% compared with 1.4% with RRP, which could be attributed to the steep Trendelenburg position used during the laparoscopic procedure or to early ambulation.[4,50] Salvage open radical prostatectomy after radiation treatment has been performed on an extremely limited basis by individuals who excel at this technique. Despite expertise, the operation is associated with high morbidity and complications due to the effects of radiation. Recently, Vallancien et al[51] performed a salvage LAP on 7 patients; no additional morbidity occurred in any patient. Minimally invasive techniques have some unique risks, but with adequate experience these seem to be similar to the complication rates of open procedures.

Cost

Data on costs associated with LAP in the United States are limited because most cost-specific studies have been performed in Europe. The differences in patient management, ie, hospitalization until removal of urinary catheter as in Europe vs discharged home with the catheter in place as in the United States, and in health care systems make extrapolating cost data unrealistic. For example, in France Guillonneau and Vallancien[6] calculated the mean costs for 100 patients undergoing LAP vs RRP and found that LAP represented a savings of $1237 (in US dollars) per case. Ruchlin and Pellissier[52] performed multiple analyses on the treatment of prostate cancer and estimated the cost of an open prostatectomy to be between $15,000 and $21,000 (in US dollars). The cost of minimally invasive approaches will likely be higher because the procedures tend to be longer and disposable materials and instruments are used. Rassweiler et al[53] estimated that the cost of advanced technology, such as telerobotic surgery, will increase the cost per case by $1500 to $2000 in the United States. Until more cost-specific data are accumulated, no conclusions pertaining to fiscal superiority can be made.

CONCLUSIONS

Minimally invasive approaches to prostatectomy are gaining momentum for the treatment of localized prostate cancer. The development and practice of these new procedures are discussed avidly by the lay public, media, and the urologic community. The technical feasibility of LAP and RAP has been proved at select experienced centers; however, many unanswered questions remain about widespread clinical use and postoperative efficacy. Because of the steep learning curve (conservatively estimated at 60-80 procedures), LAP is not performed at most US centers, especially when results with traditional open prostatectomies are excellent. In addition, patients treated during the learning curve would be subjected to unnecessary morbidity with less favorable results than they should otherwise expect. Nonetheless, LAP has made amazing strides in the past 3 years. The procedure has prompted some urologists to modify traditional prostatectomy protocols to impact the interval of postoperative catheterization. LAP seems to provide results comparable to those with open procedures with respect to margin status, blood loss, and transfusion rates. Experienced laparoscopic centers advertise continence and potency rates similar to those with open surgical procedures. As data accumulate, more valuable information regarding oncologic outcomes for disease-specific and metastasis-free survival will become available.

Although many established laparoscopic procedures have been performed extensively without prospective randomized head-to-head clinical comparisons, it is doubtful that this approach will be used for minimally invasive prostatectomy. The advancements that have made LAP so appealing have led surgeons who perform open prostatectomy to reevaluate their own procedures and experience to improve their results with a time-proven standard of care for organ-confined disease. The coexistence of multiple surgical approaches should challenge surgeons who perform open and laparoscopic procedures to work together and scientifically evaluate and advance the treatment options for prostate cancer. LAP and RAP seem to have established a role in the modern evolution of urologic practice, but outcomes equivalent or superior to those with open procedures must be obtained before they become part of the accepted armamentarium.

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