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Robotics for Pelvic Reconstruction

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Abstract

Robotic-assisted laparoscopy is increasingly used in female pelvic reconstructive surgery to combine the benefits of abdominally placed mesh for prolapse outcomes with the quicker recovery time associated with minimally invasive procedures. Level III data suggest that early outcomes of robotic sacrocolpopexy are similar to those of open sacrocolpopexy. A single randomized trial has provided level I evidence that robotic and laparoscopic approaches to sacrocolpopexy have similar short-term anatomic outcomes, although operating times, postoperative pain, and cost are increased with robotics. Patient satisfaction and long-term outcomes of both robotic and laparoscopic sacrocolpopexy are insufficiently studied despite their widespread use in the treatment of prolapse. Given the high reoperative rates for prolapse repairs, long-term follow-up is essential, and well-designed comparative effectiveness research is needed to evaluate pelvic floor surgery adequately.

Keywords

Robotic surgery; Robotics; Sacrocolpopexy; Pelvic reconstruction; Pelvic organ prolapse; Female pelvic medicine and reconstructive surgery; Pelvic floor disorders; Laparoscopy; Minimally invasive gynecology

Introduction

Over the next 40 years, nearly 5 million American women are projected to seek treatment for a pelvic floor disorder [1, 2], with an 11% to 19% lifetime risk of undergoing surgery for pelvic organ prolapse and/or urinary incontinence. Alarmingly, estimates suggest that 30% of these women will undergo reoperation [3–5]. Selecting the optimal surgical treatment for pelvic organ prolapse is complicated by known variations in success and complications and increasing data suggesting that outcomes are more closely associated with individual women's goals and expectations for surgery than with anatomic outcomes.

A recent Cochrane review on surgical treatment of pelvic organ prolapse included 40 studies but only 15 patients who underwent laparoscopic surgery and none who underwent robotic

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pelvic reconstructive surgery [6•]. Three randomized surgical trials compared outcomes of open abdominal sacrocolpopexy with those of native tissue vaginal repairs, concluding that open abdominal sacrocolpopexy is superior to vaginal sacrospinous ligament suspension [7–9]. Although sacrocolpopexy was associated with better anatomic outcomes, lower rates of recurrent prolapse, longer time to prolapse recurrence, and less postoperative dyspareunia, it was also associated with longer recovery and greater cost [6•].

Increasing numbers of surgeons and patients choose minimally invasive sacrocolpopexy to combine the benefits of abdominally placed mesh with the shorter recovery time associated with minimally invasive surgery. Early studies indicate that robotic and laparoscopic sacrocolpopexy is associated with shorter hospital stay, decreased blood loss, and similar short-term anatomic outcomes compared with open sacrocolpopexy [10, 11]; however, unlike extirpative surgery, given the high reoperation rates for prolapse, long-term follow-up is essential to adequately evaluate pelvic floor surgery. A consensus conference of pelvic floor researchers recently identified a “critically important and immediate need” for comparative effectiveness research for patients with pelvic floor disorders. In addition, this expert panel highlighted the need for long-term follow-up of “at least 5-years and preferably longer for surgical trials” and an “urgent need for research on how to manage mesh-related complications and risk factors for surgical failure” [12], as patients are often more bothered by new symptoms or complications other than persistent or recurrent prolapse [13]. These recommendations reinforce those of the 4th International Consultation on Incontinence, which noted that laparoscopic sacrocolpopexy is used as an alternative to open sacrocolpopexy, although no comparative studies have reported short-term or long-term outcomes [14].

The aim of this article is to highlight current applications, techniques, and evidence for robotically assisted laparoscopy in pelvic reconstructive surgery.

Sacrocolpopexy

Robotically assisted laparoscopic sacrocolpopexy is the most commonly performed robotic pelvic reconstructive procedure [15]. Pelvic surgeons originally introduced laparoscopic sacrocolpopexy to minimize the morbidity associated with open sacrocolpopexy while taking advantage of improved prolapse outcomes associated with mesh. Early case series reported shorter hospital stays and less blood loss but longer operating times with laparoscopic compared with open sacrocolpopexy, although complications and reoperation rates were similar [11]. Initially, longer surgeon learning curves and operative times limited widespread adoption of laparoscopic sacrocolpopexy. One paper that reviewed more than 1,000 laparoscopic sacrocolpopexies from 11 case series reported that operative times and conversion to open procedures decreased with increased surgeon experience [16]. Mean operative time ranged from 96 to 286 minutes, with a nearly 3% conversion rate. Then, in 2004, Di Marco and colleagues [17, 18] published the first case series reports on robotically assisted laparoscopic sacrocolpopexy for pelvic organ prolapse. Although these series did not report objective or subjective patient symptoms and did not quantify preoperative or postoperative prolapse findings, they demonstrated that sacrocolpopexy could be performed robotically, with a decrease in operative times from 4.75 to 2.25 hours over the first 20 cases [17].

Case series data comparing robotic and open sacrocolpopexy suggest similar short-term anatomic outcomes, shorter hospital stays, and fewer complications associated with robotic sacrocolpopexy [10, 17, 19]. A retrospective comparative study of open and robotic sacrocolpopexy using validated outcomes reported significantly better apical support in the robotic group 6 weeks after surgery [10], although the clinical significance of 1-cm

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improvement in apical support in the robotic group is questionable. In addition, robotic sacrocolpopexy was associated with shorter hospital stays and less blood loss but longer operating times than open colpopexy. However, baseline differences existed between groups: those in the robotic group had slightly more advanced anterior and apical prolapse, were more likely to undergo concomitant hysterectomy, and were less likely to undergo concomitant procedures. Although these data suggest there may be some difference in anatomic outcomes after open and robotic sacrocolpopexy, much longer follow-up is necessary. Another early case series of robotically assisted laparoscopic sacrocolpopexy reported early anatomic outcomes on 12 of 15 women with advanced prolapse who successfully underwent robotic repair; the remaining three women required a laparotomy [20]. All women had successful apical repair with postoperative pelvic organ prolapse quantification stage of 0 [21]. Most recently, a single-site, randomized trial comparing laparoscopic and robotic sacrocolpopexy in 67 women was published in abstract form [22]. The primary outcome, operative time, was longer, and postoperative pain (3–6 weeks) was greater after robotic sacrocolpopexy. Anatomic and functional outcomes were only reported at 6 months and did not differ between the groups.

While patient satisfaction, quality of life, and long-term outcomes of both laparoscopic and robotically assisted laparoscopic sacrocolpopexy using validated measures are insufficiently studied, early data attest to the feasibility of minimally invasive sacrocolpopexy for treatment of pelvic organ prolapse and suggest potentially quicker recovery with similar anatomic outcomes. These data should be interpreted cautiously, as existing studies rarely report outcomes beyond 1 year after prolapse surgery and are limited by retrospective study designs, small sample sizes, inconsistent nomenclature, nonstandardized prolapse quantification, lack of masking, and lack of validated symptom and quality-of-life measures.

Concomitant Procedures

Hysterectomy—Hysterectomy and/or stress incontinence procedures are the most commonly performed concomitant procedures at the time of robotic or laparoscopic sacrocolpopexy. In the Geller et al. [10] series, 47% of women underwent a concomitant supracervical hysterectomy and 51% a concomitant incontinence procedure. When performing a concomitant hysterectomy, most reconstructive surgeons now prefer supracervical hysterectomy to total hysterectomy in order to decrease the risk of mesh complications. A large, multicenter cohort of women undergoing open sacrocolpopexy reported a nearly fivefold increase in vaginal mesh erosion with concomitant total hysterectomy as compared with sacrocolpopexy alone for vault prolapse [23]. Similarly, a retrospective case series reported sevenfold higher mesh erosion rates after sacrocolpopexy with concomitant total hysterectomy (8%) than after sacrocolpopexy with supracervical hysterectomy (0) or vault suspension (0) [24]. This year, a retrospective series of 188 women undergoing minimally invasive sacrocolpopexy (laparoscopic or robotic) reported mesh erosion/exposure rates of 10% [25]. Subgroup analyses comparing three groups (concomitant supracervical hysterectomy, concomitant vaginal hysterectomy, and posthysterectomy) found a 5.7-fold increased odds of mesh erosion in the vaginal hysterectomy group (23%) compared with the supracervical hysterectomy (5%) and posthysterectomy groups (5%).

Continence Procedures—Concomitant continence procedures are often performed with minimally invasive sacrocolpopexy for treatment or prevention of stress urinary incontinence; however, data regarding optimal continence procedure and success rates are sparse. One large, randomized trial compared the addition of a prophylactic Burch colposuspension to open sacrocolpopexy in stress-continent women [26]. Two years after surgery, 12% of women who received a concomitant Burch reported bothersome stress incontinence, compared with 25% of those who did not receive a Burch [27]. No adequately designed trials or studies have reported outcomes of Burch colposuspension at the time of minimally invasive sacrocolpopexy for treatment or prevention of stress incontinence, likely because most surgeons opt to perform a midurethral sling concomitantly with a robotic or laparoscopic sacrocolpopexy [10]. To date, few data exist to guide surgeons in selecting the right continence procedure for the right patient at the time of minimally invasive sacrocolpopexy.

Cost

Health care costs are increasingly important when selecting optimal treatments. Studies estimating costs of robotic surgery compared with laparoscopic and open techniques consistently conclude that robotics is associated with higher costs [28•, 29, 30]. A recent cost minimization analysis compared robotic, laparoscopic, and open sacrocolpopexy [28•]. The authors created a decision model that included operative time, risk of conversion, risk of transfusion, and length of hospital stay with or without the purchase price of the robot. Robotic sacrocolpopexy was associated with higher costs regardless of whether the purchase price of the robot was included in the model. If the model did not include the robot purchase price, the cost per procedure was $8,508 for robotic, $7,353 for laparoscopic, and $5,792 for open sacrocolpopexy. Similarly, a recent abstract reporting outcomes of a single-site, randomized trial of laparoscopic and robotic sacrocolpopexy found that the costs of the robotic approach were significantly higher than those of the laparoscopic approach [22]. Data from a two-site, National Institutes of Health–funded, comparative effectiveness trial comparing costs of robotic and laparoscopic sacrocolpopexy will be available next year (http://clinicaltrials.gov/ct2/show/NCT01124916).

Advantages and Disadvantages of Robotic Assistance

Robotic technology offers enhanced three-dimensional visualization, improved dexterity and wrist-like manipulation of instruments with increased freedom of movement and elimination of tremor, and the ability to use telestration for teaching. Although these benefits have not translated directly into improved patient outcomes compared with conventional laparoscopy in pelvic floor reconstruction, results of longer-term outcome studies and the impact on training junior surgeons are not yet available. Improved visualization and dexterity afforded by the robot may decrease learning curves associated with conventional laparoscopy, leading to broader adoption of minimally invasive techniques. Likewise, robotic surgery has several unique limitations not encountered in laparoscopic or open surgery. Surgeons do not get haptic feedback or sensation when operating robotically; therefore, visual changes in tissue blanching and movement must be used to compensate for tactile differences in tissues and structures. Robotic set-up and docking require more surgical staff, expertise, and time than that usually associated with open or laparoscopic procedures. Precise port placement is more important with robotics than in conventional laparoscopy because of limitations in movement that result from improperly positioned robotic arms. Once the robot is docked (robot arms attached), the patient and the operating table cannot be moved, and the degree of Trendelenburg cannot be changed, which limits changes in positioning to assist with patient ventilation. Finally, operative times tend to be longer with robotic assistance when compared with laparoscopic and open sacrocolpopexy. Increased operative time may place patients at higher risk of adverse outcomes. A recent study of patients undergoing nephrectomy for renal cell carcinoma found that duration of surgery greater than 6 hours placed patients at a higher risk of perioperative complications and mortality, independent of patients' preoperative comorbidities, tumor extent, or intraoperative blood loss [31].

Technique

To best extrapolate known outcomes of open sacrocolpopexy to minimally invasive techniques such as robotically assisted laparoscopy, it seems logical to mimic the open procedure as closely as possible with regard to mesh type and placement, suture type, or method of attachment to sacrum. Most of the literature on robotic sacrocolpopexy includes the use of large-pore type I polypropylene mesh to affix the vagina to the anterior longitudinal ligament of the sacrum with permanent sutures [10, 19]. Erosion rates with abdominally placed polypropylene mesh are approximately 3% [32]. Open outcomes are better if a permanent mesh is attached to the anterior and posterior vaginal walls (not just the apex), then to the sacrum with permanent sutures [33, 34]. Open techniques that do not place the mesh anteriorly are associated with up to 30% anterior vaginal wall recurrence rates [34]. Similarly, sacral sutures are sometimes replaced by tacking devices during robotic and laparoscopic procedures; however, available comparative studies use sutures on the sacrum, so the outcomes of using sacral tacks are unknown [10, 22, 33].

At the start of the case, patients are placed in dorsal lithotomy position with legs positioned low in supportive stirrups. We prefer Allen PAL Pro stirrups (Allen Medical Systems, Acton, MA), as the more streamlined boot interferes less with the third robotic arm. Similarly, a low-height bariatric table optimizes movement of the third arm when the patient is in steep Trendelenburg, which can be limited by the left leg. We position the patient on a gel pad with Allen Shoulder Supports (Allen Medical Systems. Acton, MA) to prevent slippage toward the head of the bed in steep Trendelenburg.

In most cases, we use a “W” configuration for port placement to allow easy access to the lower pelvis and sacral promontory. After insufflation, the robotic camera is placed through a 12-mm laparoscopic port in the umbilicus. Two 8-mm robotic ports are inserted inferior to the umbilicus at 35- to 45-degree angles and approximately 10 cm from the umbilical port to maximize access to the pelvis and movement of the robotic arms. The final 8-mm robotic port for the third robotic arm is placed on the left side at the level of the umbilicus at a 45-degree angle from the second robotic port. An 8-mm accessory port is placed on the patient’s right side, similar to the third robotic port, to insert and remove suture.

Prior to attaching the robotic arms, the patient should be placed in maximum Trendelenburg to clear the bowels from the pelvis. Increased body mass index and inability to tolerate steep Trendelenburg for long cases may limit patient ventilation, particularly those with centripetal obesity. However, two studies found no increase in complications, duration of surgery, length of hospitalization, or estimated blood loss in obese women undergoing robotic hysterectomy or myomectomy [35, 36]. Once all ports are placed, the robotic arms are attached to each robotic port (docking). We place the robot just off the patient’s midline when docking to allow access to the vagina for sling placement and cystoscopy.

We use five or six robotic instruments, with one instrument change during most sacrocolpopexies: monopolar scissors, bipolar grasper, double fenestrated grasper, tenaculum, and two needle drivers. Hysterectomy and dissection of the bladder anteriorly, posterior peritoneum, and presacral space are done with the monopolar scissors in the first robotic arm, a bipolar grasper in the second arm, and the tenaculum or fenestrated grasper in the third arm. Once all the dissections are complete, a large suture cut needle driver is placed in the first arm and a large needle driver in the second arm. A 0-degree lens is used for most cases. Rarely, we will use a 30-degree lens in the up position to facilitate visualization of the rectovaginal space and dissection.

Fistula Repair and Ureteral Reimplantation

Increasingly, reconstructive pelvic surgeons apply the benefits of robotically assisted laparoscopy to vesico- and ureterovaginal fistula repairs and ureteral reimplantation [37–41]. These small case reports and case series demonstrate the feasibility of fistula repair and ureteral reimplantation but do not provide comparative outcome data. A single small, retrospective, comparative study suggested that length of stay and blood loss are decreased with robotic ureteral reimplantation compared with open or laparoscopic approaches [39].

Similar to the literature, we find that robotically assisted laparoscopy is a reasonable alternative to vesicovaginal fistula repairs that are not amenable to vaginal access. Port placement is similar to that described above for sacrocolpopexy. Enhanced visualization and wrist movements associated with robotics provide easy dissection of the bladder from the vagina, allowing for tension-free bladder closure and adequate space between the bladder and vagina for an omental interposition graft. Distal ureteral reimplantation is also accomplished with the "W" configuration port placement; however, port placement should be modified when the ureteral injury is more proximal. Frequently, the umbilical and one lateral port need to be placed superior to the umbilicus. Our experience is that improved visualization and dexterity afforded by the robot allow improved dissection for ureteral reimplantation in women. Our initial results are favorable, but longer-term outcomes are necessary.

Conclusions

Robotic surgery is increasingly used in pelvic reconstructive surgery to couple the benefits of abdominally placed mesh for prolapse outcomes with quicker recoveries associated with minimally invasive procedures. Level III data suggest that early outcomes of robotic sacrocolpopexy are similar to those of open sacrocolpopexy. A single randomized trial (level I evidence) also suggests that robotic sacrocolpopexy has similar short-term anatomic outcomes to the laparoscopic approach, although operating times, postoperative pain, and costs are increased with robotics. Patient satisfaction and long-term outcomes of both robotic and laparoscopic sacrocolpopexy are insufficiently studied despite their widespread use in the treatment of prolapse Given the high reoperation rates for reconstructive surgery for prolapse, long-term follow-up is essential, and well-designed comparative effectiveness research is needed to adequately evaluate outcomes of pelvic floor surgery.

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