Short-Term Outcomes of Robotic Sacrocolpopexy Compared With Abdominal Sacrocolpopexy

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OBJECTIVE: To compare short-term outcomes of robotic sacrocolpopexy with abdominal sacrocolpopexy for vaginal vault prolapse.

METHODS: We conducted a retrospective cohort study comparing robotic to abdominal sacrocolpopexy with placement of permanent mesh. The primary outcome was vaginal vault support on 6-week postoperative pelvic organ prolapse quantification (POP-Q) system examination. Secondary outcomes included blood loss, operative time, length of stay, blood transfusion, pulmonary embolus, gastrointestinal or genitourinary tract injury, ileus, bowel obstruction, postoperative fever, pneumonia, wound infection, and urinary retention.

RESULTS: The analysis included 178 patients (73 robotic and 105 abdominal sacrocolpopexy). There were no differences in age, race, or body mass index. Robotic sacrocolpopexy showed slight improvement on POP-Q “C” point (–9 compared with –8, \(P<.008\)) when compared with abdominal sacrocolpopexy and was associated with less blood loss (103±96 mL compared with 255±155 mL, \(P<.001\)), longer total operative time (328±55 minutes compared with 225±61 minutes, \(P<.001\)), shorter length of stay (1.3±0.8 days compared with 2.7±1.4 days, \(P<.001\)), and a higher incidence of postoperative fever (4.1% compared with 0.0%, \(P=.04\)). There were no differences in other secondary outcomes. Operative time remained significantly greater in the robotic group (\(P<.001\)), and estimated blood loss remained lower (\(P<.001\)) when controlling for possible confounders.

CONCLUSION: Robotic sacrocolpopexy demonstrated similar short-term vaginal vault support compared with abdominal sacrocolpopexy, with longer operative time, less blood loss, and shorter length of stay. Long-term data are needed to assess the durability of this new minimally invasive procedure.

(Obstet Gynecol 2008;112:1201–6)

LEVEL OF EVIDENCE: II

With our aging population, the rate of pelvic organ prolapse is steadily increasing.\(^1\) In the United States, each year over 200,000 women undergo procedures for surgical correction of prolapse.\(^2\) Combining this number with a nearly 30% lifetime risk of reoperation for recurrent prolapse, the need for an effective surgical procedure is in high demand.\(^3\) Currently, the abdominal sacrocolpopexy is thought to be the most effective procedure for surgical correction of vaginal vault prolapse, based on efficacy and long-term durability.\(^1\)

In the last several years, focus has turned to a minimally invasive approach to the sacrocolpopexy.\(^4,5\) Laparoscopy has become a forerunner in the pursuit of improving surgical outcomes by reducing postoperative pain and decreasing recovery time. However, the use of laparoscopic instruments can be cumbersome and unwieldy, thereby increasing operative time and reducing dexterity, which can limit the surgeon’s ability to perform the procedure with the same techniques that can be accomplished through a traditional abdominal incision. In 2005, U.S. Food and Drug Administration approval was obtained for...
use of the daVinci robot (Intuitive Surgical, Inc., Sunnyvale, CA) for use in gynecologic surgery as a modification of the laparoscopic approach. This robot employs the use of robotic arms that control modified laparoscopic instruments that have seven degrees of freedom, giving the surgeon significantly improved dexterity. The advent of this technology has made it possible to perform the traditional sacrocolpopexy through a minimally invasive technique that still allows for ease of maneuvering, thus combining the benefits of a durable surgical repair with a shorter recovery period.

Our primary aim was to compare short-term outcomes in patients undergoing robotic sacrocolpopexy compared with abdominal sacrocolpopexy for advanced vaginal vault prolapse, based on 6-week postoperative assessment of prolapse. Our secondary aim was to compare the incidence of intraoperative and short-term postoperative complications between the two groups at 6 weeks.

METHODS

After approval by the Institutional Review Boards at the University of North Carolina at Chapel Hill (UNC) and Duke University, we conducted a retrospective cohort study comparing outcomes for patients who had undergone either a robotic sacrocolpopexy or an abdominal sacrocolpopexy for vaginal vault prolapse. Data were collected between January 2004 and March 2008 from patients seen in the Divisions of Urogynecology and Reconstructive Pelvic Surgery at UNC and Duke University.

Techniques for robotic sacrocolpopexy have been described previously.6,7 These studies describe a laparoscopic approach for dissection of the vaginal and sacral planes, followed by docking of the robot for attachment of the mesh to the vagina and sacrum. Two operative robotic ports and two laparoscopic ports were used for the procedure. Our technique involves the use of three operative robotic ports with one laparoscopic assistant port for the introduction of sutures and mesh, as well as assistance with the procedure. This leads to a total of five ports (including the robotic camera port). An initial survey is performed laparoscopically before docking the robot and any enterolysis is performed laparoscopically. This requires experience with laparoscopy that supersedes any robotic experience. All operative dissections and suturing are performed robotically. This includes development of the vesicovaginal, rectovaginal, and presacral spaces and attachment of mesh to the anterior and posterior vagina and anterior longitudinal ligament of the sacrum. If a hysterectomy was performed for uterine prolapse, a concurrent robotic hysterectomy was performed. The majority of these were supracervical, with uterine morcellation.

An end-to-end anastomosis sizer is placed in the vagina during the procedure to better delineate the cuff. The bladder and rectum are sharply dissected off the anterior and posterior vagina for several centimeters before placement of the mesh. IntePro large pore polypropylene “Y” mesh (American Medical Systems, Minnetonka, MN) is the graft material we use to perform the colpexy. It is composed of two pieces of polypropylene mesh sewn together in a “Y” configuration. Multiple interrupted CV-2 Gore-Tex (W. L. Gore & Associates, Inc., Flagstaff, AZ) sutures are used to attach the short arms of the “Y” mesh to the anterior and posterior aspects of the vaginal cuff. The distal end of the mesh is then attached to the anterior longitudinal sacral ligament with three to four interrupted sutures of CV-2 Gore-Tex. The peritoneum is then reaproximated over the mesh to avoid direct contact with the peritoneal cavity with 2–0 absorbable suture in an attempt to reduce bowel obstruction. The same technique and materials are used to perform the abdominal sacrocolpopexy, with the exception of standard polypropylene mesh compared with the preconfigured “Y” mesh. All patients received perioperative antibiotic prophylaxis.

Between March 2006 and March 2008 there were 73 robotic sacrocolpexies performed by one attending surgeon (A.G.V.) at the two institutions with fellow and resident involvement. During the first year that these procedures were performed, they took place at UNC, whereas during the second year they were performed at Duke University. Beginning in March 2006, all sacrocolpexies performed by this attending surgeon were robotic. Patients who had undergone a robotic sacrocolpopexy at either institution were contacted regarding their willingness to participate in the study. The control group comprised patients who had undergone an abdominal sacrocolpopexy at UNC by an attending surgeon in the Division of Urogynecology and Reconstructive Pelvic Surgery. The data regarding patient outcomes in the control group were obtained by review of the medical record for patients who underwent abdominal sacrocolpopexy.

The primary outcome was vaginal vault support assessed by an attending surgeon at a 6-week postoperative visit with the Pelvic Organ Prolapse Quantification (POP-Q) system examination.8 Point “C” on the POP-Q refers to either uterine or vaginal cuff support; whereas points “Aa” and “Ba” refer to support of the anterior vaginal wall, and points “Ap” and “Bp” refer to support of the posterior vaginal wall. Positive values signify prolapse that protrudes beyond the introitus, whereas negative values signify less...
severe prolapse that remains within the vagina. A value of 0 indicates prolapse that comes to the introitus but does not protrude externally. Secondary outcomes for this study included blood loss, operative time (skin incision to bandage placement), length of stay, blood transfusion, pulmonary embolus, genitourinary or gastrointestinal tract injury, ileus, bowel obstruction, postoperative fever (temperature greater than 38.0°C on two occasions greater than 24 hours postoperatively), pneumonia, wound infection, and urinary retention (defined by failed voiding trial). All diagnoses were based on clinical determination as documented in the medical record. These secondary outcomes were assessed during the first 6 weeks after surgery. It is of note that perioperative and postoperative practice patterns were consistent over the 4-year span of the study, including administration of voiding trials and discharge criteria.

A review of the paper medical record was conducted to investigate short-term outcomes, including operative time, estimated blood loss, intraoperative and postoperative complications (listed above), length of hospital stay, and readmission. We also reviewed the electronic medical record for demographic information and preoperative and postoperative physical examination of vaginal vault support as measured by the POP-Q examination.

Inclusion criteria for the study group included a diagnosis of vaginal vault prolapse with a history of having undergone a robotic sacrocolpopexy at one of the two institutions. There were no exclusions for prior prolapse surgery or concomitant prolapse or incontinence surgery.

Data were analyzed using SPSS 16.0 (SPSS Inc., Chicago, IL) with $\chi^2$, Fisher exact, Student $t$, Mann-Whitney $U$, and Wilcoxon signed rank as well as multiple linear regression analyses, with the alpha value set at 0.05.

RESULTS
The analysis included 178 patients (73 in the robotic sacrocolpopexy group and 105 in the abdominal sacrocolpopexy group). There were no differences in age, race, or body mass index between groups (Table 1). Women in the robotic group had more significant prolapse on preoperative POP-Q examination: C ($+3$ compared with $+1$, $P=.002$), Ba ($+2$ compared with $+1$, $P=.001$), and Bp ($+2.5$ compared with 0, $P=.005$). They were also more likely to undergo hysterectomy and less likely to undergo other concomitant procedures for prolapse. Concomitant procedures included hysterectomy, antiincontinence surgery, and other prolapse surgery. There was no difference in the rate of antiincontinence surgery. One robotic case was converted to an abdominal route before docking of the robot due to extensive intraabdominal adhesions (but this case remained in the robotic group for analysis).

Postoperatively, robotic sacrocolpopexy was associated with a slight improvement in C point ($-9$ compared with $-8$, $P=.008$), but no difference in other POP-Q points when compared with abdominal sacrocolpopexy (Table 2). When comparing preoperative POP-Q to postoperative POP-Q for the robotic sacrocolpopexy group alone, there was significant
Robotic sacrocolpopexy was also associated with less blood loss, longer total operative time, and a shorter length of stay when compared with abdominal sacrocolpopexy (Table 2). Among the other secondary outcomes, there was a higher incidence of postoperative fever in the robotic sacrocolpopexy group. There were no significant differences in the other secondary outcome measures. It is of note that the genitourinary tract injuries included a single cystotomy in each group. The cystotomy that occurred during the robotic surgery was repaired robotically in two layers without complication. Universal cystoscopy was the standard in both groups. No ureteral injuries occurred.

In a multiple linear regression model that controlled for body mass index, hysterectomy, other concomitant prolapse surgery, antiincontinence surgery, and lysis of adhesions, operative time remained significantly greater in the robotic group (P<.001). Concomitant hysterectomy (P=.03). In a regression model controlling for the same covariates, estimated blood loss remained significantly lower in the robotic group (P<.001). Concomitant hysterectomy (P=.02) and antiincontinence surgery (tension-free mesh sling or Burch urethropexy) (P=.003) were each found to increase estimated blood loss in this model.

**DISCUSSION**

Robotic sacrocolpopexy is a new technique that offers certain advantages over the traditional abdominal sacrocolpopexy. These include less morbidity from the minimally invasive approach in terms of less blood loss and shorter hospital stay. Advantages over laparoscopy include increased visualization and dexterity. Contraindications for robotic surgery are similar to those for laparoscopic surgery, namely inability to tolerate general anesthesia and steep Trendelenburg position. A history of significant prior abdominal surgery is usually not a contraindication, especially with the increased dexterity of the robotic instruments, with the limiting factor being access to the peritoneal cavity. Overall, robotic surgery offers a promising advancement in the evolution of the minimally invasive laparoscopic approach to traditional pelvic reconstructive support surgeries.

Others have reported on their experience with robotic sacrocolpopexy.6,7,9–11 These studies are limited to case series and reports on operative complications, conversion rates, and outcomes. None of these studies with samples sizes ranging from 12 to 25 patients include a comparison group, but rather describe their

**Table 2. Operative Outcomes**

<table>
<thead>
<tr>
<th></th>
<th>Robotic Sacrocolpopexy (n=73)</th>
<th>Abdominal Sacrocolpopexy (n=105)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postoperative POP-Q</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>-9 (-10 to -8)</td>
<td>-8 (-9 to -8)</td>
<td>.008*</td>
</tr>
<tr>
<td>Aa</td>
<td>-3 (-3 to -3)</td>
<td>3 (-3 to -3)</td>
<td>.38</td>
</tr>
<tr>
<td>Ba</td>
<td>-3 (-3 to -3)</td>
<td>-3 (-3 to -3)</td>
<td>.29</td>
</tr>
<tr>
<td>Ap</td>
<td>-3 (-3 to -2)</td>
<td>-3 (-3 to -2)</td>
<td>.67</td>
</tr>
<tr>
<td>Bp</td>
<td>-3 (-3 to -2)</td>
<td>-3 (-3 to -2)</td>
<td>.55</td>
</tr>
<tr>
<td>Blood loss (mL)</td>
<td>103±96</td>
<td>255±155</td>
<td>&lt;.001†</td>
</tr>
<tr>
<td>Operative time (min)</td>
<td>328±55</td>
<td>225±61</td>
<td>&lt;.001†</td>
</tr>
<tr>
<td>Length of stay (d)</td>
<td>1.3±0.8</td>
<td>2.7±1.4</td>
<td>&lt;.001†</td>
</tr>
<tr>
<td>Transfusion</td>
<td>1 (1.4)</td>
<td>4 (3.8)</td>
<td>.65†</td>
</tr>
<tr>
<td>Pulmonary embolus</td>
<td>1 (1.4)</td>
<td>0 (0)</td>
<td>.41†</td>
</tr>
<tr>
<td>Genitourinary tract injury (cystotomy)</td>
<td>1 (1.4)</td>
<td>1 (1.0)</td>
<td>1.00‡</td>
</tr>
<tr>
<td>Gastrointestinal tract injury</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>1.00‡</td>
</tr>
<tr>
<td>Ileus</td>
<td>4 (5.5)</td>
<td>2 (1.9)</td>
<td>.23‡</td>
</tr>
<tr>
<td>Bowel obstruction</td>
<td>0 (0)</td>
<td>2 (1.9)</td>
<td>.51‡</td>
</tr>
<tr>
<td>Postoperative fever</td>
<td>3 (4.1)</td>
<td>0 (0)</td>
<td>.04‡</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>2 (2.7)</td>
<td>3 (2.9)</td>
<td>1.00‡</td>
</tr>
<tr>
<td>Wound infection</td>
<td>2 (2.7)</td>
<td>3 (2.9)</td>
<td>1.00‡</td>
</tr>
<tr>
<td>Urinary retention</td>
<td>0 (0)</td>
<td>1 (1.0)</td>
<td>1.06†</td>
</tr>
</tbody>
</table>

POP-Q, pelvic organ prolapse quantification.
Data are median (25% to 75%), mean±standard deviation, or n (%).
* Mann-Whitney U test.
† Student t test.
‡ Fisher exact test.
outcomes associated with robotic sacrocolpopexy. Operative times have been reported in case series of sacrocolpopexy as well as case series of hysterectomies. Operative times for robotic sacrocolpopexy ranging from 172 minutes for Ayaz et al to 192 minutes for Elliott. Reynolds and Advincula reported a median operative time of 242 minutes for robotic hysterectomy (12 total and four subtotal hysterectomies). Although these operative times are shorter than what we report, approximately one half of our robotic surgeries involved concurrent procedures, including robotic hysterectomy and suburethral mesh sling. These additional procedures certainly added to the operative time. Our cases also took place at academic institutions that involved direct teaching and hands-on participation of clinical fellows and at times residents at the robotic console, under direct supervision of the attending surgeon (A.V.). This undoubtedly increases the operative time. We cannot comment on whether similar hands-on instruction took place at the other institutions. Ayaz et al reported on colpophysteropexy, which they described as attaching mesh to the vagina and broad ligament of the uterus. There were no concurrent procedures performed. Elliott et al reported on sacrocolpopexy, with no concurrent hysterectomies and 40% undergoing sling placement. The difference in the number of total procedures performed and the element of hands-on training of clinical fellows may explain the difference seen in operative time.

Daneshgari at al reported on estimated blood loss at the time of robotic colpopexy or uteropexy with a mean of 81 mL (50–150 mL). This is similar to our average of 103 mL. They did have a 64% rate of sling placement, but did not perform any concurrent hysterectomies. As stated previously, our reported blood loss included all procedures performed. When including only cases that underwent robotic colpopexy (with no concurrent procedures), our mean estimated blood loss was 69 mL, compared with 412 mL in the abdominal sacrocolpopexy group. In terms of robotic hysterectomy, Reynolds and Advincula reported on blood loss with their case series of robotic hysterectomy, change in hematocrit may not be an accurate assessment of actual blood loss. It is postulated that this finding may be due to the longer operative time found in the robotic group, which may lead to increased release of pyrogenic cytokines, such as interleukin 1 and 6, tumor necrosis factor, and interferon-γ. Overall, the rate of fever was low in the robotic group (4.1%). There were no differences in clinically relevant infectious complications such as pneumonia or wound infection.

A limitation of this study is its retrospective design. However, the risk of recall bias is reduced by the fact that all data were gathered from the medical record and did not rely on patient recall. There is also a potential for misclassification bias, but we would expect this bias to be nondifferential between the robotic and abdominal groups. We were not powered to adequately assess our secondary outcomes. We are able to comment on the differences observed but not for several variables where the overall incidence was low in both groups. Larger comparative trials would be necessary to adequately compare such secondary outcomes.

Another limitation may be the fact that our control group is not derived from the same time period as our study group. We wanted to control for confounders by using cases performed by the same group of surgeons using the same technique and materials for the two procedures. Thus, we chose a historical cohort of patients who had undergone the abdominal sacrocolpopexy over a 2-year period at UNC. An additional limitation may be the use of estimated blood loss instead of change in hematocrit to determine actual blood loss. This decision was based on the fact that postoperative hematocrit was not consistently available at both institutions. However, because preoperative hematocrit is usually measured approximately 2 weeks before surgery, change in hematocrit may not be an accurate assessment of actual blood loss either. Finally, another limitation may be the fact that the majority of robotic hysterectomies performed were supracervical, whereas the majority of abdominal hysterectomies were total. However, there were significantly more hysterectomies performed in the robotic group. If there is any bias introduced by this difference, it would most likely be in favor of the abdominal group. Our decision to perform supracervical hysterectomy was based on a desire to
decrease the risk of mesh erosion, although there is also no clear answer on whether supracervical hysterectomy has a lower risk of mesh erosion than total hysterectomy when performed concurrently with sacrocolpopexy. In terms of mesh erosion, there was no difference between groups at 6 weeks, although we were not powered to detect this difference. This outcome will be followed and reported along with the other outcomes when we report our 1-year data. Previous studies have found conflicting results in regard to hysterectomy as a factor in mesh erosion when performed at the same time as sacrocolpopexy (Cundiff G, Varner E, Visco AG, Zyczynski HM, Nager CW, Norton PA, et al. Risk factors for mesh/suture erosion following sacrocolpopexy. Am J Obstet Gynecol, in press). Cundiff et al. (Cundiff G, Varner E, Visco AG, Zyczynski HM, Nager CW, Norton PA, et al. Risk factors for mesh/suture erosion following sacrocolpopexy. Am J Obstet Gynecol, in press) found concurrent total hysterectomy to be a risk factor for mesh erosion at the time of sacrocolpopexy. Wu et al. found an increased risk of mesh erosion with total hysterectomy but only in those receiving estrogen therapy. Sarlos et al. found no increased risk of mesh erosion with concurrent laparoscopic supracervical hysterectomy.

The major strength of this retrospective cohort study is the fact that we report on outcomes of robotic sacrocolpopexy in comparison with a control group of patients who underwent abdominal sacrocolpopexy, the criterion standard for advanced vaginal vault prolapse. It is critical to include a control group for comparison to assess the efficacy of this newer minimally invasive surgical technique. It is worth noting that the control group in this study comprised patients at the same institution, exposed to the same practice patterns regarding perioperative care, including similar surgical technique, antibiotic prophylaxis, and postoperative discharge guidelines as the robotic group. Another strength of this study is the use of objective data, in the form of POP-Q scores, for outcome assessment. This minimizes bias that may be introduced by the retrospective design of the study.

Robotic sacrocolpopexy demonstrated similar short-term vaginal vault support compared with abdominal sacrocolpopexy, with less blood loss and shorter length of stay. Operative time was longer but may decrease as the learning curve for this new procedure improves. There were similar outcomes between the two groups in terms of perioperative complications, but this is limited by the low incidence of these complications. Long-term data are needed to assess the durability of this newer minimally invasive approach to prolapse repair.

REFERENCES