ELSEVIER

JMIG The Journal of Minimally Invasive Gynecology

Review Article

Sacrocolpopexy for Treatment of Vaginal Apical Prolapse: Evidence-Based Surgery

Ilana L. Parkes, MBBS(Hons), and David Shveiky, MD*

From the Section of Female Pelvic Medicine and Reconstructive Surgery, Department of Obstetrics and Gynecology, Hadassah–Hebrew University Medical Center, Ein Kerem, Jerusalem, Israel (both authors).

ABSTRACT Pelvic organ prolapse is a common condition that negatively affects womens' quality of life. Sacrocolpopexy is an abdominal procedure designed to treat apical compartment prolapse including uterine or vaginal vault prolapse and multiple-compartment prolapse. Although traditionally performed as an open abdominal procedure, minimally invasive sacrocolpopexy, whether laparoscopic or robotic, has been successfully adopted in the practice of many pelvic reconstructive surgeons. There are many variations to this procedure, with different levels of evidence to support each of them. Herein we review the current literature on sacrocolpopexy, with emphasis on the minimally invasive approach. Procedural steps and controversies are examined in light of the existing literature, and recommendations are made on the basis of the level of existing evidence. Journal of Minimally Invasive Gynecology (2014) 21, 546–557 © 2014 AAGL. All rights reserved.

Keywords: Evidence; Laparoscopy; Mesh; Robotic surgery; Sacrocolpopexy; Surgical technique

DISCUSS You can discuss this article with its authors and with other AAGL members at http://www.AAGL.org/jmig-21-4-JMIG-D-13-00408

Use your Smartphone to scan this QR code and connect to the discussion forum for this article now*

* Download a free QR Code scanner by searching for "QR scanner" in your smartphone's app store or app marketplace.

Pelvic organ prolapse (POP) is a common condition that negatively affects the quality of life (QoL) of up to 40% of all women [1,2]. Many surgical procedures have been designed to treat multiple-compartment prolapse; however, high-quality data comparing outcomes of these procedures are scant [3,4]. Repeat operation rates for prolapse surgery are high, in particular in the anterior and apical compartments [2]. In an attempt to improve anatomical cure rates, biologic and synthetic mesh grafts have been developed to improve tissue strength. Mesh can be implanted via the abdominal or vaginal route, and use of vaginal mesh has become popular during the past decade because of its minimal invasiveness and satisfactory anatomical outcomes. However, conflicting data on the use of vaginal mesh cast some doubt on the benefit of this technology. Vaginal mesh seems to improve anatomical outcome at the anterior and apical compartments; however, most studies have failed to demonstrate subjective improvement in symptoms and QoL after repair using vaginal mesh compared with native tissue [5]. Moreover, the US Food and Drug Administration recently issued a public health notification stating that serious adverse events are not rare in vaginal mesh surgery. In its review of the literature, abdominal prolapse repair using mesh was found to be associated with fewer mesh-specific complications than was vaginal prolapse repair using mesh [6], a finding that, at least in relation to mesh complications, supports the abdominal approach as a potentially safer and more effective means of repairing POP.

Abdominal sacrocolpopexy (ASC), first described in 1957 by Lane to treat vaginal vault prolapse after hysterectomy, is considered the most durable procedure for repair of POP, with reported long-term success rates of 68% to 100% [7]. In this procedure, an abdominal approach is used to attach a mesh graft to the anterior and posterior walls of the vagina and to anchor it to the anterior longitudinal ligament at the sacral promontory. Despite its excellent cure rates and durability, the potential morbidity associated with this open abdominal procedure has motivated surgeons and researchers to evaluate more minimally invasive

Corresponding author: David Shveiky, MD, Department of Obstetrics and Gynecology, Hadassah–Hebrew University Medical Center, Ein Kerem, Jerusalem, Israel.
E-mail: dhsveiky@hadassah.org.il

Submitted July 19, 2013. Accepted for publication January 6, 2014.
Available at www.sciencedirect.com and www.jmig.org

1553-4650/$ - see front matter © 2014 AAGL. All rights reserved.
http://dx.doi.org/10.1016/j.jmig.2014.01.004

approaches. ASC can also be performed laparoscopically, with reported short-term cure rates similar to those obtained using the open approach [8]. However, this procedure involves extensive suturing and retroperitoneal dissection requiring advanced laparoscopic skills. In robotic sacrocolpopexy (RSC), a new tool, the da Vinci Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA), is used for performance of minimally invasive POP repair. This approach incorporates the potential durability of abdominal repair with the minimal invasiveness of robotic surgery. Short-term data show that RSC is safe and efficacious, with short-term anatomical outcome comparable to that with the open and laparoscopic approaches [9–15]. While adhering to the basic principles of this procedure, many variations in surgical technique exist; however, good quality data to support one technique over the other are limited.

We reviewed the current literature on sacrocolpopexy, with focus on efficacy and safety, effect of patient risk factors on outcome, and data on minimally invasive approaches to this procedure. In addition, although most data are for the open procedure, we highlight specific surgical steps and issues involved in the minimally invasive approaches of laparoscopy and robotics as they apply to sacrocolpopexy.

Patient Selection

Sacrocolpopexy is a procedure designed to repair apical support defects. Although originally described as a treatment for vaginal vault prolapse, it is widely used today for treatment of uterine prolapse as well. In uterine prolapse, hysterectomy is usually completed before sacrocolpopexy. Uterine preservation or hysteropexy is not discussed in this review. In many instances of anterior and posterior vaginal wall prolapse, there is also an apical component. Careful patient evaluation is required to diagnose multiple-compartment prolapse. Such diagnosis is crucial for selection of the most appropriate surgical option.

The role of sacrocolpopexy as primary surgery for prolapse has never been consistently studied. Because patients with more advanced prolapse are at higher risk of recurrence [15], sacrocolpopexy, with its high durability and success rates, may be considered a good option for primary repair.

As compared with vaginal prolapse repair, sacrocolpopexy, either open or laparoscopic/robotic, is generally a longer procedure that requires that the patient be under general anesthesia and in a steep Trendelenburg position. Therefore, some patients with medical comorbidities may not be considered ideal candidates for the procedure. In patients with surgical risk factors, the benefits of this longer surgery should be weighed against its risks, in particular when there are potentially safer and less invasive alternatives via the vaginal route [5]. In these patients at high risk, sacrocolpopexy may be reserved for recurrent prolapse as a secondary treatment option; however, this has not been proved by scientific data. The durability of sacrocolpopexy and its potential benefits for sexual function (preservation of vaginal length and axis and lower rate of dyspareunia) make this procedure a good option in relatively young, sexually active women. In a study comparing RSC with vaginal mesh colpopexy, patients who underwent RSC were more likely to be younger, leaner, and sexually active and to have fewer medical comorbidities [16]. This reflects surgeon preference to select younger and healthier patients for sacrocolpopexy. No randomized trial exists to support this practice. Recent data challenge traditional beliefs about some surgical risk factors. A study by Bradley et al [17] showed that most outcomes and complication rates after open sacrocolpopexy were similar in obese women and those with healthy weight. Another study showed that in elderly women robotic surgery was associated with fewer postoperative complications than was vaginal surgery. The authors concluded that either the vaginal or robotic route may be reasonable in the elderly population [18]. The surgeon should be aware of the variety of surgical risk factors, including advanced age, obesity, and medical comorbidities, in selecting the procedure of choice for prolapse repair.

Efficacy of Sacrocolpopexy

ASC is considered one of the most durable procedures for repair of vaginal vault prolapse. In a comprehensive review of ASC in 2004, Nygaard et al [7] reported cure rates of 78% to 100% when defined as lack of apical prolapse postoperatively, and 58% to 100% when defined as no postoperative prolapse. Since the publication of this frequently cited comprehensive review of ASC, many studies have been performed to evaluate this procedure, with some of them providing high-quality data. More studies have rigorously assessed pelvic symptoms, urinary tract and bowel function, sexual function, and QoL using standardized and validated tools. In addition, newer studies have been published that assessed minimally invasive laparoscopic or robotic-assisted sacrocolpopexy.

In a randomized controlled trial (RCT) comparing sacrocolpopexy with and without Burch colposuspension to prevent stress urinary incontinence, the Colpopexy and Urinary Reduction Efforts (CARE) trial, Brubaker et al [14] reported cure rates as high as 95% at the vaginal apex in women at 2 years after ASC. At 2 year follow-up, $<4\%$ of women required a repeat operation to treat prolapse [14]. Patient satisfaction rate and QoL measures also showed sustainable improvement from baseline. ASC compares favorably with vaginal procedures for apical suspension such as sacrospinous fixation. A 2010 Cochrane review reported a lower rate of recurrent vault prolapse, reduced grade of residual prolapse, greater interval before prolapse recurred, and less dyspareunia with ASC vs apical prolapse repair [5]. Another study, by Maher et al [19], that compared laparoscopic sacrocolpopexy (LSC) with repair using total vaginal mesh also demonstrated superior results for sacrocolpopexy; at 2-year follow-up the objective cure of LSC was 77%, compared with 43% in the vaginal mesh group. The repeat operation rate was 5%, compared with 22% after the vaginal mesh procedure [19]. A recent prospective study

from France reported the effect of LSC on symptoms, QoL, and sexuality. The Pelvic Floor Distress Inventory (PFDI-20) score improved substantially at 3 and 12 months after LSC. QoL, as reflected by the Pelvic Floor Impact Questionnaire (PFIQ-7), was also substantially improved, as was sexual function as reflected by the Pelvic Organ Prolapse Urinary Incontinence Sexual Questionnaire (PISQ-12) [20].

In contrast to the improvement in prolapse symptoms, urinary tract symptoms, and QoL that is generally observed after sacrocolpopexy, the effect of sacrocolpopexy on bowel symptoms is less clear. In a retrospective study of 77 women who underwent RSC, only 56% reported improvement in outlet constipation at 1 year postoperatively. In addition, 11.6% had de novo outlet constipation [21].

It is important to note that when defining success of a procedure in subjective terms, such as improvement in patient symptoms, QoL, and satisfaction, the lack of uniformity in outcome measuring tools and the subjectivity of outcomes make it difficult to draw clear conclusions. Keeping this limitation in mind, Nygaard et al [7] reported patient satisfaction or complete relief of symptoms to be as high as 85% to 100%.

The issue of follow-up in studies involving sacrocolpopexy also deserves mention because both duration and completeness of follow-up varies considerably between studies. In 2002, Culligan et al [22] performed a large retrospective cohort study with 245 patients who had undergone sacrocolpopexy, with specific focus on follow-up in an effort to establish the natural history of the procedure. That investigation found that almost 95% of objective failures occur within the first 24 months after surgery, a conclusion that highlights the importance of long-term follow-up studies of $\geq$2 years [22]. A recent long-term follow-up study of CARE trial participants by Nygaard et al [23] concluded that at 7-year follow-up there was an increased rate of failure of ASC on both objective and subjective measures. The authors also calculated the probability of mesh erosion over 7-year follow-up to be 10.5% [23].

Minimally Invasive Sacrocolpopexy

The primary disadvantages of ASC, that is, relatively high complication rate, longer hospital stay, more postoperative pain, and delayed return to activity [5], have led many surgeons to limit or completely abandon the abdominal approach to POP repair in their practice. The need for a minimally invasive procedure that incorporates the cure rate and durability of abdominal repair has recently been addressed by the accumulating data on LSC and RSC. In both of these procedures, all surgical principles of ASC are followed, but using a minimally invasive approach. In a recent RCT from Britain that compared open vs LSC, the 2 procedures demonstrated similar anatomical success rates for LSC, with less blood loss, higher hemoglobin concentration, and shorter hospital stay [24]. In addition, these procedures are generally believed to be associated with better cosmetic results [25]. Nevertheless, the necessity of high-level laparoscopic skills may limit the popularity of this procedure.

RSC using the da Vinci Surgical System is a new technique for performance of minimally invasive sacrocolpopexy, and may overcome some of the difficulties associated with conventional laparoscopy. Since its approval by the US Food and Drug Administration in 2005, the da Vinci robot has gained popularity among pelvic reconstructive surgeons, enabling more surgeons to perform minimally invasive sacrocolpopexy. There is evidence that surgical tasks may be more easily learned by trainees in the robotic system as compared with conventional laparoscopy. In 2011, Kho [26] reviewed the literature on surgical task acquisition and performance on the robotic platform as compared with conventional laparoscopy. That author concluded that in the laboratory setting the learning curve was less steep with the robotic platform than with conventional laparoscopy; however, this is yet to be proved in a clinical setting.

The robotic system offers improved visualization with 3-dimensional view and substantially improved dexterity owing to the wide motion and articulation range of the robotic tip unit. The primary disadvantage of the robotic system is the higher cost as compared with that of ASC or LSC. Another important disadvantage of the robotic system is lack of haptic feedback during surgery. In recent years, clinical data have been accumulating in the literature with regard to surgical outcomes of LSC and RSC, and demonstrate comparable outcomes to ASC in the treatment of POP. Tables 1 and 2 summarize data on LSC and RSC, respectively, which are discussed in more detail as follows.

Minimally Invasive vs Open Sacrocolpopexy

In a recent prospective study of 148 women undergoing LSC, the anatomical cure rate was 93.7% at 12 months [20]. In a recent large study comparing LSC and RSC vs ASC among Medicare beneficiaries, minimally invasive sacrocolpopexy was associated with a higher rate of repeat operation to repair anterior wall prolapse than was ASC (3.4% vs 1%; $p = .02$). However, more medical (primarily cardiopulmonary) complications were reported after surgery in the open group (31.5% vs 22.7%; $p = .02$) [38]. Elliot et al [10] reported success rates of 94% in a series of 30 patients undergoing RSC with follow-up of up to 24 months. Belsante et al [36] reported no recurrent vault prolapse and a statistically significant improvement in reported QoL in 35 patients who underwent RSC, with a median follow-up of 28 months. More recently Geller et al [12] reported similar short-term vaginal vault support with RSC and open sacrocolpopexy, with longer operative time, less blood loss, and shorter length of stay with RSC. A follow-up study of the same cohort at 44 months demonstrated comparable long-term rates of success for both open and robotic procedures, using both objective and subjective measures [34]. Freeman et al [24] performed a multiple-center RCT in the UK, comparing LSC vs ASC. The subjective cure rate for ASC

Table 1

Summary of studies on laparoscopic sacrocolpopexy outcome

Source, year	Design	No. of women	Duration of follow-up, mo	Outcome/Cure rate	Complications	Remarks
Sarlos et al [8], 2008	Retrospective cohort	101 46 laparoscopic supracervical hysterectomy + sacrocolpopexy 55 LSC	12	93% Subjective 98% Objective	NA	Recurrence only in anterior compartment (6%)
Maher et al [19], 2011	RCT	53 LSC 55 Vaginal mesh	24	Objective: 77% LSC 43% vaginal mesh	NA	NA
Tan Kim et al [27], 2011	Retrospective cohort	188 LSC or RSC	NA	See complications	Total 10% rate of mesh erosion Rate significantly higher in TLH vs supracervical hysterectomy or post-hysterectomy	Primary outcome: risk factors for mesh erosion
Warner et al [28], 2012	Retrospective cohort	390	NA	See complications	Functional GI complications 1% (1 ileus, 3 SBO) Prolonged nausea/emesis 0.8% Bowel injury 1.3% (3 small bowel injuries, 2 rectal injuries)	Primary outcome: GI complications
Warner et al [29], 2012	Retrospective cohort	390	NA	See complications	Mesh exposure rate 2.8%; higher rate associated with total vs supracervical hysterectomy and with laparoscopic vs vaginal mesh suturing Suture extrusion rate 3.6%; higher rate associated with laparoscopic vs vaginal mesh suturing	Primary outcome: mesh exposure
Ramanah et al [30], 2012	Prospective cohort	90 LSC	30	Postoperative worsened Colorectal-Anal Distress Inventory ($p = .02$) No change in Colorectal-Anal Impact Questionnaire ($p = .37$)	NA	Primary outcome: anorectal symptoms
Withagen et al [31], 2012	Prospective cohort	49 45 LSC 4 laparoscopic sacrohysteropexy	6	98% Objective (apical compartment) 79% Subjective (apical compartment)	1 Patient (2%). mesh exposure 1 Patient (2%) small bowel injury	Study examined efficacy of LSC with bone anchor fixation

(*Continued*)

Table 1

Continued

Source, year	Design	No. of women	Duration of follow-up, mo	Outcome/Cure rate	Complications	Remarks
Culligan et al [32], 2013	RCT	115 57 Porcine dermis 58 Polypropylene mesh	12	Porcine dermis: 80.7% Objective 84.2% Subjective Polypropylene mesh: 86.2% Objective 89.7% Subjective	NA	No statistically significant difference between groups
Freeman et al [24], 2013	Multiple-center RCT	NA	12	Subjective cure 90% ASC 80% LSC (NS)	Less blood loss and shorter hospital stay in LSC	RCT comparing ASC and LSC

ASC = abdominal sacrocolpopexy; GI = gastrointestinal; LSC = laparoscopic sacrocolpopexy; NA = not available or not applicable; NS = not significant; RCT = randomized controlled trial; RSC = robotic sacrocolpopexy; SBO = small bowel obstruction.

was 90%, and for LSC was 80% (not significant), with less blood loss and a shorter hospital stay for LSC. Siddiqui et al [35] recently showed an outcome of RSC, performed by a single surgeon, similar to the outcome of ASC in patients who participated in the CARE trial.

Laparoscopic vs Robotic Sacrocolpopexy

In a small retrospective study, we compared short-term outcome and operative time between conventional laparoscopic and robotic sacrocolpopexy. Similar anatomical cure rates were found in the 2 groups. Further, there was no difference in the rate of perioperative complications or operating time [13]. In contrast, in an RCT, Paraiso et al [33] reported longer operating time and increased postoperative pain after RSC compared with the conventional laparoscopic approach, although with similar anatomical outcomes. Insofar as costs, the authors found that RSC was $1936 more than LSC. However, a different cost analysis concluded that with sufficient institutional case volume, RSC can be even less costly than open ASC [39].

To date, given the existing evidence regarding outcome of LSC and RSC, both procedures should be considered comparable, and the choice to perform each of them is made on the basis of personal preference and surgeon skills.

Complications

Complications of ASC include general surgical complications as well as some more unique to the procedure. In their review of open ASC, Nygaard et al [7] found a total complication rate of 14.6%. The more important complications associated with sacrocolpopexy are discussed here in further detail.

It should be noted that open ASC is associated with a higher rate of medical complications, in particular cardiopulmonary complications, as compared with LSC or RSC [26]. In addition, a systematic review that focused on complications and repeat operation rates concluded that the rate of overall serious complications requiring repeat operation, as measured using the Dindo grading system, is lower in sacrocolpopexy vs prolapse surgery performed vaginally, either with native tissue or mesh [40].

Bleeding Complications

During presacral dissection, bleeding may occur from the iliac vessels and, unique to this procedure, from the middle sacral vessels at the sacral promontory. Nygaard et al [7] described this complication as “uncommon” but “one of the most worrisome.” The overall median rate of bleeding complications was 4.4% [7].

Urinary Tract Complications

In the review of sacrocolpopexy by Nygaard et al [7], the most common complication reported was urinary tract

Table 2

Summary of studies on robotic sacrocolpopexy outcome

Source, Year	Design	No. of women	Duration of follow-up	Outcome/Cure rate	Complications	Remarks
Di Marco et al [11], 2004	Retrospective cohort	5	4 mo	No recurrence	NA	NA
Elliott et al [10], 2006	Retrospective cohort	30	24 mo	100% Subjective	1 Recurrent grade 3 rectocele 1 Recurrent vaginal vault prolapse 2 Mesh erosion	NA
Daneshgari et al [9], 2007	Retrospective cohort	12	6 mo	100% Objective Mean POP-Q Bp point +1.3 → –2.65 C point +2.1 → –8.28	NA	NA
Geller et al [12], 2008	Retrospective cohort	178 73 RSC 105 ASC	6 wk	RSC improved POP-Q C point Less blood loss	RSC: higher incidence of postoperative fever	ASC vs RSC
Shveiky et al [15], 2010	Retrospective cohort	54 17 RSC 37 Vaginal mesh colpopexy	12 mo	Objective cure: RSC 94.1% Vaginal mesh 70.2%	Similar complication rates	RSC vs vaginal mesh colpopexy
Paraiso et al [33], 2011	RCT	78 38 LSC 40 RSC	12 mo	Similar objective cure rates	RSC: higher postoperative pain and use of NSAIDs	NA
Geller et al [34], 2012	Retrospective cohort	51 23 RSC 28 ASC	44 mo	Similar objective improvement	RSC: mesh erosion 8% ASC: mesh erosion 7%	Long-term outcome of RSC vs ASC
Siddiqui et al [35], 2012	Retrospective cohort	447 125 RSC 322 ASC	12 mo	Composite outcome (cure = no bulge symptoms and no repeat surgery) RSC 92% ASC 96% (NS) Anatomical cure 94% for both	NA	Comparison of single-surgeon RSC and ASC outcome from CARE trial
Antosh et al [13], 2012	Retrospective cohort	88 65 RSC 12 LSC	3 mo	RSC: 87.1% objective LSC: 91.3% objective (NS)	Similar rates of complications	RSC vs LSC
Belsante et al [36], 2013	Retrospective cohort	35 RSC	28 mo	Objective improvement POP-Q C point mean –1.1 → –9.7 Subjective improvement ($p < .05$)	No recurrent vaginal vault prolapse 3 Repeat pelvic organ prolapse procedures 1 Mesh erosion	NA
Salamon et al [37], 2013	Prospective cohort	120 RSC	12 mo	89% Objective 94% Subjective	No mesh complications	Ultra-lightweight polypropylene mesh in RSC

ASC = abdominal sacrocolpopexy; CARE = Colpopexy and Urinary Reduction Efforts trial; LSC = laparoscopic sacrocolpopexy; NA = not available or not applicable; NS = not significant; NSAID = nonsteroidal anti-inflammatory drug; POP-Q = pelvic organ prolapse quantification; RCT = randomized controlled trial; RSC = robotic sacrocolpopexy.

infection, with a median rate of 10.9%. Injury to the urinary tract is less common but not rare. In 11 studies that reported bladder injury, the median rate was 3.1%. The reported median rate of damage to the ureter was 1.0%; however, only 4 studies discussed this complication.

Gastrointestinal Complications

A secondary analysis of the CARE trial, focusing on gastrointestinal complications of ASC, found that 5.9% of participants experienced serious gastrointestinal complications such as small bowel obstruction or ileus. Only 1.2% required a repeat operation because of serious gastrointestinal complications. The authors noted that this rate of serious gastrointestinal complications for ASC is comparable to that for other open gynecologic procedures. In that study, no intraoperative bowel injuries were reported [41]. Nygaard et al [7] noted a median rate of bowel injury of 1.6%. Similarly, in a recent retrospective study that focused on gastrointestinal complications of LSC in 390 patients, Warner et al [29] found a rate of 1.3% for intraoperative bowel injury (3 small bowel and 2 rectal injuries). That study reported a rate of 1% for combined ileus and small bowel obstruction. Previous abdominal surgery was positively associated with functional gastrointestinal complications such as ileus, small bowel obstruction, and nausea, but not with bowel injury.

Mesh Complications

In their systematic review, Jia et al [42] reported that mesh erosion rates for sacrocolpopexy varied between 0% and 12%. This compared with rates of 0% to 21% for infracoccygeal sacropexy. In their 2004 review of ASC, Nygaard et al [7] reported an overall rate of mesh erosion of 3.4%. Similarly, Visco et al [14] reported the rate of mesh erosion for ASC to be 3.2%, compared with 4.5% for abdominal sacral colpoperineopexy (in which the posterior mesh is attached to the perineum), and >16% for procedures in which the mesh was sutured vaginally. In that study the mean time to diagnosis of mesh erosion in the ASC group was 15.6 months [43].

Vertebral Discitis

Vertebral discitis at the L5–S1 level, or even osteomyelitis, may occur as a result of mesh or suture placement in the sacral area. This is a rare but serious complication that may necessitate a repeat operation for debridement and removal of the infected mesh. There have been several reports of this complication [44–46]. Muffly et al [46] reported a case of lumbosacral osteomyelitis that manifested with increasing back pain and foul-smelling vaginal drainage. Such cases have been reported up to 5 years after surgery.

Nerve Injury

LSC and RSC may be associated with additional complications that are unique to the laparoscopic approach. In both procedures the patient is lying in the lithotomy position in a steep Trendelenburg position for a prolonged time. As a result, there is increased risk of position-related nerve injury, in particular to the posterior tibial and femoral nerves in the lower limbs and to the brachial plexus at the upper limbs and shoulder girdle [47]. Special measures should be taken to prevent such injuries, including proper patient positioning, prevention of the patient sliding down the table during the procedure, and minimizing operative time.

Common Surgical Controversies

Hysterectomy: Total vs Supracervical

In patients with uterine prolapse, many surgeons prefer to perform hysterectomy before sacrocolpopexy. When uterine preservation is desired, sacrohysteropexy may be considered; however, discussion of this procedure is beyond the scope of this article. While total hysterectomy may have the advantage of prevention of future cervical disease, supracervical hysterectomy may be an alternative after exclusion of cervical dysplasia. Although sometimes offered as a safer alternative to total hysterectomy, this assertion is not supported by level 1 evidence. None of 3 randomized trials that compared open supracervical vs total hysterectomy demonstrated significant differences in perioperative morbidity or in urinary or sexual function [48]. However, in a retrospective study, laparoscopic supracervical hysterectomy was associated with less blood loss and complications when compared with laparoscopically assisted vaginal hysterectomy [49]. In theory, from the pelvic support perspective, the residual apical support provided by the uterosacral ligaments may also be an advantage [50].

In an analysis of 322 participants in the CARE trial, concurrent total hysterectomy was found to be a modifiable risk factor for mesh erosion after sacrocolpopexy [51]. In another retrospective study of 390 LSCs, open cuff hysterectomy was significantly associated with mesh erosion, as compared with supracervical hysterectomy (4.9% vs 0%; $p = .03$) [29]. With regard to vaginal hysterectomy, Tan Kim et al [27] found this to be a significant risk factor for mesh erosion in sacrocolpopexy, with up to 23% erosion rates.

Recommendation

Overall, it seems that when hysterectomy is indicated, supracervical hysterectomy may have a benefit over total hysterectomy or transvaginal hysterectomy in reducing mesh erosion and overall complication rates. Level of evidence: 2b.

Choice of Graft and Suture Material

Several studies have addressed the question of which graft material should be used in ASC. Tate et al [52] conducted an RCT that compared cadaveric fascia lata graft vs synthetic polypropylene mesh for ASC. At 5-year follow up, objective anatomical success rates were 62% for fascia

lata graft, and 93% for polypropylene mesh (p = .02) [52]. In a recent RCT, Culligan et al [32] compared surgical outcome of laparoscopic sacrocolpopexy using either porcine dermis or polypropylene mesh. They found similar objective cure rates of 80.7% and 89.2%, respectively (not significant). A retrospective study by Quiroz et al [53] found more apical failures in ASC with use of porcine acellular collagen matrix graft (11%) as compared with polypropylene mesh (1%) or autologous fascia (7%). All repeat operations occurred in the porcine acellular collagen matrix group. This graft was also associated with higher graft-related complications [53]. In a recent prospective study, Salamon et al [37] found objective and clinical cure rates of 89% and 94%, respectively, in RSC using ultra-lightweight polypropylene mesh, with no mesh complications.

Significant heterogeneity also exists between different synthetic mesh products [54]. A recent study compared the ex-vivo strength, stiffness, and degree of permanent deformation of 7 different commercial vaginal meshes. In general, meshes of lighter weight (i.e., more porous meshes) were less stiff but had decreased tensile strength [54]. Nevertheless this was an ex vivo study on which we cannot base clear clinical recommendations.

Insofar as suture selection, one study found no suture or mesh erosion in 254 patients in whom monofilament delayed absorbable suture (PDS; Ethicon, Inc., Somerville, NJ) was used, as compared with 3.7% when braided permanent suture (Ethibond; Ethicon) was used, with a similar anatomical outcome in the 2 groups [55]. In a case series of 22 patients with infected mesh after ASC, 15 had a polytetrafluoroethylene mesh (Gore-Tex; W.L. Gore and Associates, Inc., Newark, DE). In 82% of them, the mesh was attached to the vagina using a braided permanent suture [56]. To facilitate suturing, unidirectional barbed sutures are sometimes used in sacrocolpopexy for attaching the mesh to the vagina or for peritoneal covering of the mesh. One study has shown its feasibility and safety in pelvic reconstructive surgery; however, the existing data are insufficient to draw any conclusion [57].

Recommendations

- Polypropylene mesh is superior to fascia lata graft in ASC. Level of evidence: Ib.
- Porcine dermis and polypropylene mesh yield comparable short-term cure rates in LSC. Level of evidence: Ib.
- ASC is more likely to fail with use of a porcine acellular collagen matrix graft than with synthetic or autologous grafts. Level of evidence: 2b.
- Use of ultra-lightweight polypropylene mesh for RSC may limit mesh-related complications in the first postoperative year, with substantial improvement in subjective and objective outcomes. Level of evidence: 2b.
- Monofilament delayed absorbable sutures may reduce suture or mesh erosion rates in ASC. Level of evidence: 2b.

Y-Mesh vs 2 Separate Mesh Pieces

Use of a preformed Y-mesh may facilitate mesh placement and shorten the procedure; however, many surgeons prefer to use 2 separate pieces of mesh for the anterior and posterior vagina. The advantage of this approach is that each piece can be individually tensioned at the surgeon's preference. There are no data in the literature that compare these 2 approaches.

Recommendation

There is no evidence to support using either preformed Y-mesh or 2 separate mesh pieces for sacrocolpopexy. This controversy is yet to be studied.

How Low in the Vagina Should the Graft be Placed?

One of the most common controversies about the technique of sacrocolpopexy is the extent of dissection and mesh placement in the vagina. Although many surgeons dissect the vesicovaginal space to the level of the urethrovaginal junction, and the rectovaginal space to the level of the levator ani muscles, others choose to limit this dissection in an attempt to reduce the risk of cystotomy or enterotomy. The value of low mesh placement in both the anterior and posterior compartments has not been examined in a RCT. In 1997, Cundiff et al [58] described the abdominal sacral colpoperineopexy procedure for correction of a posterior defect and perineal descent. In this procedure, the rectovaginal space was dissected to the superior aspect of the posterior vaginal fascia still contiguous with the perineal body, and synthetic mesh was sutured to the posterior vagina. At short-term follow-up, 8 of 11 patients reported improved bowel symptoms. Nevertheless, in an evaluation of the long-term effect of this procedure on obstructive defecatory symptoms by the same researchers, 85% of patients reported obstructed defecation at 5-year follow-up. The authors concluded that sacral colpoperineopexy is not likely to eliminate obstructed defecatory symptoms [58]. In a French prospective study of 90 patients undergoing laparoscopic sacral colpoperineopexy, anorectal symptoms worsened substantially at 30.7 months of follow-up [59]. De novo straining (27%) and the need for digital assistance (17%) were the most frequent anorectal symptoms [59]. In their retrospective study of mesh erosion after ASC, Visco et al [43] found no difference in mesh erosion rates between ASC and sacral colpoperineopexy when the mesh was sutured abdominally.

Recommendation

On the basis of prospective non-randomized studies, abdominal and laparoscopic sacral colpoperineopexy is associated with no improvement, and even worsening, of obstructive defecatory symptoms. Level of evidence: 2b.

Sacrocolpopexy for Treatment of Anterior Compartment Prolapse

Many patients with apical prolapse also have anterior vaginal prolapse [60]. Correction of the vaginal apical support is important in any prolapse repair. In sacrocolpopexy, mesh graft is sutured to the anterior and posterior vaginal walls. Although most recurrences of prolapse occur in the anterior wall, only a small number of studies have specifically addressed cure of an anterior wall defect as a primary outcome. Some surgeons added paravaginal repair to ASC to correct cystocele. In a survey of 963 members of the American Urogynecologic Society, most responders considered the anterior vaginal graft sufficient to address cystocele at abdominal sacrocolpopexy [61]. In a retrospective cohort study comparing outcomes in 170 patients undergoing sacrocolpopexy with and without concomitant paravaginal repair, Shippey et al [62] were unable to detect a statistically significant difference in the recurrence rate of cystocele between the groups. In another retrospective study, Gilleran et al [63] reported an 8% recurrence rate for cystocele at 6 months after ASC, with substantial improvement in all compartments.

Recommendation

Anterior mesh placement at sacrocolpopexy may be sufficient for cystocele repair. Level of evidence: 2b.

Concomitant Posterior Repair during Sacrocolpopexy

Elevating the vaginal apex may correct support defects at the anterior and posterior vaginal walls. A study by Guiahi et al [64] measured the topography of the anterior and posterior vaginal walls using the pelvic organ prolapse quantification system before and 1 year after ASC. The anterior compartment was the most common site of POP persistence or recurrence, followed by the posterior compartment and the vaginal apex. Those authors found ASC sufficient to restore posterior vaginal wall support in most women, without concomitant posterior repair [64]. Another study by Crane et al [21] compared defecatory symptoms, specifically, outlet obstruction, in patients who underwent RSC with and without concomitant posterior repair. There was no difference between the groups in obstructive symptoms or in symptomatic posterior wall prolapse at 1 year after RSC. Overall, 11.7% underwent subsequent posterior repair, none of whom underwent posterior repair during the initial surgery (not significant) [21].

Recommendations

- Posterior vaginal wall defect is often corrected at ASC, with no need for concomitant posterior repair. Level of evidence: 2b.
- Concomitant posterior repair has no effect on outlet obstruction symptoms after RSC. Level of evidence: 2b.
- There is a trend toward reduced need for subsequent posterior repair in women who underwent this procedure during the initial surgery. Level of evidence: 2b.

Sacral Fixation Techniques

In ASC, the mesh is fixed to the anterior longitudinal ligament at the sacral promontory. The optimal number of sutures required to secure the mesh to the ligament has not been studied. Insofar as suture placement and orientation, White et al [65] performed a cadaver study and found that sutures placed at or above the sacral promontory are more secure than those placed below it. Horizontally oriented sutures were substantially stronger than vertically placed sutures [65]. In relation to suture position, however, it should be noted that although fixation at or above the sacral promontory may result in a stronger stitch, increasingly cephalad suture placement has been demonstrated substantially alter the vaginal axis to a less anatomic position [66]. Furthermore, the increasing proximity to the great vessels may increase the risk of injury to them.

Another potential complication of sacral fixation is lumbosacral discitis at the level of L5–S1. Abernethy et al [67] performed a magnetic resonance imaging study to examine the sacral promontory and its relation to the intervertebral disks. They found the intervertebral disk to be located at the promontory in 53% of participants. Those authors suggested that suture placement strategies that avoid this location may reduce disk-related sequelae after sacrocolpopexy [67]. Recently, Good et al [68] showed similar results in a cadaver study. They found the L5–S1 disk to be the most prominent structure in the presacral space. During sacrocolpopexy, the surgeon should recognize the 60-degree average drop between the anterior surfaces of L5 and S1 and avoid the L5–S1 disk [67]. When placing the sutures caudal to the true sacral promontory, down the slope of the sacrum, it is recommended to attach them to S1 rather than S2, based on a study that found the pullout strength of sutures to be substantially higher at the S1 level than at the S2 level [69].

The use of bone anchors for securing of the mesh to the presacral area is gaining popularity because it may save time and avert the need for laparoscopic suturing. In a prospective cohort study, Withangen et al [31] reported excellent objective outcomes (98%) at the apical compartment at 6 months after LSC using bone anchor fixation, with no osteomyelitis or discitis. It seems that the fear of L5–S1 discitis with bone anchor screws is not based on solid data but on a few case reports [70]. Despite this, were discitis to occur, management by removing bone anchors may be more difficult than removing simple sutures.

Recommendations

- Sutures placed at or above the sacral promontory have a stronger pullout force. Sutures placed more cephalad

have a stronger pullout force than those placed more caudally. However, more cephalad placement of sutures may result in deviation of the vaginal axis. Level of evidence: 5.
- Horizontally oriented sutures are stronger than vertical sutures. Level of evidence: 5.
- The most prominent point of the sacral promontory is the L5–S1 disk, and this area should be avoided when placing sacrocolpopexy sutures. Level of evidence: 5.
- The pullout strength of sutures placed at the S1 level is substantially higher than at the S2 level. Level of evidence: 5.
- Bone anchor fixation of the mesh is associated with good anatomical outcomes, with only case reports of lumbosacral discitis. Level of evidence: 2c.

Amount of Tension in the Vagina

One of the most critical steps in sacrocolpopexy is determination of the appropriate amount of apical suspension without undue tension that may cause pain or de novo stress incontinence. In a comprehensive review of the literature, we found no studies that addressed the issue of optimizing vaginal tension.

Peritoneal Covering of Mesh

After the vaginal vault is suspended, most practitioners cover the mesh with peritoneum in an attempt to prevent bowel entrapment and internal hernia. This complication has been reported in case reports [71]. In their case series of 128 women undergoing ASC or LSC without burial of the mesh by peritoneal closure, Elneil et al [72] reported no bowel complications. They concluded that it seems safe to perform vault suspension without closing the peritoneum (level of evidence: 2C) [72]. Nevertheless, most surgeons do cover the mesh with peritoneum to reduce potential morbidity of bowel entrapment and pelvic adhesion. We cannot recommend changing this practice on the basis of a single case series and therefore prefer to cover the mesh.

What to do in the Event of Bladder or Bowel Injury

In the event of cystotomy or proctotomy during sacrocolpopexy, the surgeon faces the dilemma of whether to abort or to continue the procedure after repairing the injury. Aborting the procedure may leave the patient with prolapse, increasing her dissatisfaction with the procedure. However, placing mesh over a repaired bladder or bowel or after bowel resection may increase the risk of mesh infection, erosion of the injured organ, or fistula formation. In the previously cited case series of mesh infection after ASC, 1 case occurred after bowel resection [53].

Currently, there are no data in the literature to direct the best practice in case of bladder or bowel injury. This important controversy should be examined in a multicenter study because these complications are not uncommon.

Use of Vaginal Estrogen Preoperatively and Postoperatively

Vaginal estrogen is widely used to treat atrophic vaginitis and is commonly used as an initial treatment of vaginal mesh erosion. The rationale for this treatment is that replacing estrogen in the vagina may minimize surgical site wound infections by altering the vaginal flora to premenopausal levels [73].

In a basic animal study by Higgins et al [74], estrogen replacement administered in ovariectomized rats reversed atrophic changes in the vagina and increased collagen deposition into polypropylene mesh. In a small RCT that examined the histologic and cytologic effects of preoperative vaginal estrogen in women with POP, Vaccaro et al [75] found a statistically significant increase in vaginal maturity index after 7 weeks of use, but no increase in vaginal epithelial thickness. The clinical significance of this finding is unclear. In a recent review of complications and their prevention, de Tayrac et al [76] concluded that there is no evidence to recommend routine local or systemic estrogen therapy before or after prolapse surgery using mesh. This common practice should be studied in a high-quality RCT to assess its clinical relevance.

In conclusion, abdominal sacrocolpopexy is one of the best-studied procedures for POP repair. It has been found to be the most effective treatment for apical prolapse and should be considered the criterion standard procedure for this condition. Minimally invasive LSC or RSC seems to have a comparable short-term outcome as the open abdominal approach and affords patients the well-recognized advantages of minimally invasive surgery. Although the surgical principles remain the same, there are variations in surgical technique. Keeping patient safety in mind, adequate training in minimally invasive surgery, as well as critical reading of the scientific data, is necessary to achieve the best surgical outcome.

References

1. Nygaard I, Barber MD, Burgio KL, et al., Pelvic Floor Disorders Network. Prevalence of symptomatic pelvic floor disorders in US women. *JAMA*. 2008;300:1311–1316.
2. Olsen AL, Smith VJ, Bergstorm JO, Colling JC, Clark AL. Epidemiology of surgically managed pelvic organ prolapse and urinary incontinence. *Obstet Gynecol*. 1997;127:380–387.
3. van Raalte HM, Lucente VR, Molden SM, Haff R, Murphy M. One-year anatomic and quality-of-life outcomes after the Prolift procedure for treatment of posthysterectomy prolapse. *Am J Obstet Gynecol*. 2008; 199:694.e1–694.e6.
4. Sung VW, Rogers RG, Schaffer JI, et al., Society of Gynecologic Surgeons Systematic Review Group. Graft use in transvaginal pelvic organ prolapse repair: a systematic review. *Obstet Gynecol*. 2008;112: 1131–1142.
5. Maher C, Feiner B, Baessler K, Adams EJ, Hagen S, Glazener CMA. Surgical management of pelvic organ prolapse in women [update in

Cochrane Database Syst Rev. 2013;(4):CD004014]. *Cochrane Database Syst Rev.* 2010;(4). CD004014.
6. US Food and Drug Administration. FDA Public Health Notification: serious complications associated with transvaginal placement of surgical mesh in repair of pelvic organ prolapse and stress urinary incontinence. http://www.fda.gov/medicaldevices/safety/alertsandnotices/publichealthnotification/ucm061976.htm.
7. Nygaard IE, McCreery R, Brubaker L, et al., Pelvic Floor Disorders Network. Abdominal sacrocolpopexy: a comprehensive review. *Obstet Gynecol*. 2004;104:805–823.
8. Sarlos D, Brandner S, Kots L, Gygax N, Schaer G. Laparoscopic sacrocolpopexy for uterine and post-hysterectomy prolapse: anatomical results, quality of life and perioperative outcome; a prospective study with 101 cases. *Int Urogynecol J Pelvic Floor Dysfunct*. 2008;19:1415–1422.
9. Daneshgari F, Kefer JC, Moore C, Kaouk J. Robotic abdominal sacrocolpopexy/sacrouteropexy repair of advanced female pelvic organ prolapse (POP): utilizing POP-quantification-based staging and outcomes. *BJU Int*. 2007;100:875–879.
10. Elliott DS, Krambeck AE, Chow GK. Long-term results of robotic assisted laparoscopic sacrocolpopexy for the treatment of high grade vaginal vault prolapse. *J Urol*. 2006;176:655–659.
11. Di Marco DS, Chow GK, Gettman MT, Elliott DS. Robotic-assisted laparoscopic sacrocolpopexy for treatment of vaginal vault prolapse. *Urology*. 2004;63:373–376.
12. Geller EJ, Siddiqui NY, Wu JM, Visco AG. Short-term outcomes of robotic sacrocolpopexy compared with abdominal sacrocolpopexy. *Obstet Gynecol*. 2008;112:1201–1206.
13. Antosh DD, Grotzke SA, McDonald MA, et al. Short-term outcomes of robotic versus conventional laparoscopic sacral colpopexy. *Female Pelvic Med Reconstr Surg*. 2012;18:158–161.
14. Brubaker L, Nygaard I, Richter HE, et al. Two-year outcomes after sacrocolpopexy with and without Burch to prevent stress urinary incontinence. *Obstet Gynecol*. 2008;112:49–55.
15. Shveiky D, Iglesia CB, Sokol AI, Kudish BI, Gutman RE. Robotic sacrocolpopexy versus vaginal colpopexy with mesh: choosing the right surgery for anterior and apical prolapse. *Female Pelvic Med Reconstr Surg*. 2010;16:121–127.
16. Whiteside JL, Weber AM, Meyn LA, Walters MD. Risk factors for prolapse recurrence after vaginal repair. *Am J Obstet Gynecol*. 2004;191:1533–1538.
17. Bradley CS, Kenton KS, Richter HE, et al., Pelvic Floor Disorders Network. Obesity and outcomes after sacrocolpopexy. *Am J Obstet Gynecol*. 2008;199:690.e1–690.e8.
18. Robinson BL, Parnell BA, Sandbulte JT, Geller EJ, Connolly A, Matthews CA. Robotic versus vaginal urogynecologic surgery: a retrospective cohort study of perioperative complications in elderly women. *Female Pelvic Med Reconstr Surg*. 2013;19:230–237.
19. Maher CF, Feiner B, DeCuyper EM, Nichlos CJ, Hickey KV, O'Rourke P. Laparoscopic sacral colpopexy versus total vaginal mesh for vaginal vault prolapse: a randomized trial. *Am J Obstet Gynecol*. 2011;204:360.
20. Thibault F, Costa P, Thanigasalam R, et al. Impact of laparoscopic sacrocolpopexy on symptoms, health-related quality of life and sexuality: a medium-term analysis. *BJU Int*. 2013;112:1143–1149.
21. Crane AK, Geller EJ, Matthews CA. Outlet constipation 1 year after robotic sacrocolpopexy with and without concomitant posterior repair. *South Med J*. 2013;106:409–414.
22. Culligan PJ, Murphy M, Blackwell L, Hammons G, Graham C, Heit MH. Long-term success of abdominal sacral colpopexy using synthetic mesh. *Am J Obstet Gynecol*. 2002;187:1473–1480.
23. Nygaard I, Brubaker L, Zyczynski HM, et al. Long-term outcomes following abdominal sacrocolpopexy for pelvic organ prolapse. *JAMA*. 2013;309:2016–2024.
24. Freeman RM, Pantazis K, Thomson A, et al. A randomised controlled trial of abdominal versus laparoscopic sacrocolpopexy for the treatment of post-hysterectomy vaginal vault prolapse: LAS study. *Int Urogynecol J*. 2013;24:377–384.
25. Yeung PP Jr, Bolden CR, Westreich D, Sobolewski C. Patient preferences of cosmesis for abdominal incisions in gynecologic surgery. *J Minim Invasive Gynecol*. 2013;20:79–84.
26. Kho RM. Comparison of robotic-assisted laparoscopy versus conventional laparoscopy on skill acquisition and performance. *Clin Obstet Gynecol*. 2011;54:376–381.
27. Tan Kim J, Menefee SA, Luber KM, Nager CW, Lukacz ES. Prevalence and risk factors for mesh erosion after laparoscopic-assisted sacrocolpopexy. *Int Urogynecol J*. 2011;22:205–212.
28. Warner WB, Vora S, Alonge A, Welgoss JA, Hurtado EA, von Pechmann WS. Intraoperative and postoperative gastrointestinal complications associated with laparoscopic sacrocolpopexy. *Female Pelvic Med Reconstr Surg*. 2012;18:321–324.
29. Warner WB, Vora S, Hurtado EA, Welgoss JA, Horbach NS, von Pechmann WS. Effect of operative technique on mesh exposure in laparoscopic sacrocolpopexy. *Female Pelvic Med Reconstr Surg*. 2012;18:113–117.
30. Ramanah R, Ballester M, Chereau E, Bui C, Rouzier R, Daraï E. Anorectal symptoms before and after laparoscopic sacrocolpoperineopexy for pelvic organ prolapse. *Int Urogynecol J*. 2012;23:779–783.
31. Withagen MI, Vierhout ME, Mannaerts GH, van der Weiden RM. Laparoscopic sacrocolpopexy with bone anchor fixation: short-term anatomic and functional results. *Int Urogynecol J*. 2012;23:481–486.
32. Culligan PJ, Salamon C, Priestley JL, Shariati A. Porcine dermis compared with polypropylene mesh for laparoscopic sacrocolpopexy: a randomized controlled trial. *Obstet Gynecol*. 2013;121:143–151.
33. Paraiso MF, Jelovsek JE, Frick A, Chen CC, Barber MD. Laparoscopic compared with robotic sacrocolpopexy for vaginal prolapse: a randomized controlled trial. *Obstet Gynecol*. 2011;118:1005–1013.
34. Geller EJ, Parnell BA, Dunivan GC. Robotic vs abdominal sacrocolpopexy: 44-month pelvic floor outcomes. *Urology*. 2012;79:532–536.
35. Siddiqui NY, Geller EJ, Visco AG. Symptomatic and anatomic 1-year outcomes after robotic and abdominal sacrocolpopexy. *Am J Obstet Gynecol*. 2012;206:435.e1–435.e5.
36. Belsante M, Murray S, Dillon B, Zimmern P. Mid term outcome of robotic mesh sacrocolpopexy. *Can J Urol*. 2013;20:6656–6661.
37. Salamon CG, Lewis C, Priestley J, Gurshumov E, Culligan PJ. Prospective study of an ultra-lightweight polypropylene Y mesh for robotic sacrocolpopexy. *Int Urogynecol J*. 2013;24:1371–1375.
38. Khan A, Alperin M, Wu N, et al. Comparative outcomes of open versus laparoscopic sacrocolpopexy among Medicare beneficiaries. *Int Urogynecol J*. 2013;24:1883–1891.
39. Elliott CS, Hsieh MH, Sokol ER, Comiter CV, Payne CK, Chen B. Robot-assisted versus open sacrocolpopexy: a cost-minimization analysis. *J Urol*. 2012;187:638–643.
40. Diwadkar GB, Barber MD, Feiner B, Maher C, Jelovsek JE. Complication and reoperation rates after apical vaginal prolapse surgical repair: a systematic review. *Obstet Gynecol*. 2009;113(2 Pt 1):367–373.
41. Whitehead WE, Bradley CS, Brown MB, et al. Gastrointestinal complications following abdominal sacrocolpopexy for advanced pelvic organ prolapse. *Am J Obstet Gynecol*. 2007;197:78.e1–78.e7.
42. Jia X, Glazener C, Mowatt G, et al. Systematic review of the efficacy and safety of using mesh in surgery for uterine or vaginal vault prolapse. *Int Urogynecol J*. 2010;21:1413–1431.
43. Visco AG, Weidner AC, Barber MD, et al. Vaginal mesh erosion after abdominal sacral colpopexy. *Am J Obstet Gynecol*. 2001;184:297–302.
44. Downing KT. Vertebral osteomyelitis and epidural abscess after laparoscopic uterus-preserving cervicosacropexy. *J Minim Invasive Gynecol*. 2008;15:370–372.
45. Weidner AC, Cundiff GW, Harris RL, Addison WA. Sacral osteomyelitis: an unusual complication of abdominal sacral colpopexy. *Obstet Gynecol*. 1997;90(4 Pt 2):689–691.
46. Muffly TM, Diwadkar GB, Paraiso MF. Lumbosacral osteomyelitis after robot-assisted total laparoscopic hysterectomy and sacral colpopexy. *Int Urogynecol J*. 2010;21:1569–1571.

47. Shveiky D, Aseff JN, Iglesia CB. Brachial plexus injury after laparoscopic and robotic surgery. *J Minim Invasive Gynecol*. 2010;17:414–420.
48. American College of Obstetricians and Gynecologists Committee on Gynecologic Practice. Supracervical hysterectomy. ACOG Committee Opinion No. 388. November 2007.
49. El-Mowafi D, Madkour W, Lall C, Wenger JM. Laparoscopic supracervical hysterectomy versus laparoscopic-assisted vaginal hysterectomy. *J Am Assoc Gynecol Laparosc*. 2004;11:175–180.
50. Chen L, Ashton-Miller JA, Hsu Y, DeLancey JO. Interaction among apical support, levator ani impairment, and anterior vaginal wall prolapse. *Obstet Gynecol*. 2006;108:324–332.
51. Cundiff GW, Varner E, Visco AG, et al., Pelvic Floor Disorders Network. Risk factors for mesh/suture erosion following sacral colpopexy. *Am J Obstet Gynecol*. 2008;199:688.e1–688.e5.
52. Tate SB, Blackwell L, Lorenz DJ, Steptoe MM, Culligan PJ. Randomized trial of fascia lata and polypropylene mesh for abdominal sacrocolpopexy: 5-year follow-up. *Int Urogynecol J*. 2011;22:137–143.
53. Quiroz LH, Gutman RE, Shippey S, et al. Abdominal sacrocolpopexy: anatomic outcomes and complications with Pelvicol, autologous and synthetic graft materials. *Am J Obstet Gynecol*. 2008;198:557.e1–557.e5.
54. Shepherd JP, Feola AJ, Abramowitch SD, Moalli PA. Uniaxial biomechanical properties of 7 different vaginally implanted meshes for pelvic organ prolapse. *Int Urogynecol J*. 2012;23:613–620.
55. Shepherd JP, Higdon HL 3rd, Stanford EJ, Mattox TF. Effect of suture selection on the rate of suture or mesh erosion and surgery failure in abdominal sacrocolpopexy. *Female Pelvic Med Reconstr Surg*. 2010;16:229–233.
56. Mattox TF, Stanford EJ, Varner E. Infected abdominal sacrocolpopexies: diagnosis and treatment. *Int Urogynecol J Pelvic Floor Dysfunct*. 2004;15:319–323.
57. Shah HN, Nayyar R, Rajamahanty S, Hemal AK. Prospective evaluation of unidirectional barbed suture for various indications in surgeon-controlled robotic reconstructive urologic surgery: Wake Forest University experience. *Int Urol Nephrol*. 2012;44:775–785.
58. Cundiff GW, Harris RL, Coates K, Low VH, Bump RC, Addison WA. Abdominal sacral colpoperineopexy: a new approach for correction of posterior compartment defects and perineal descent associated with vaginal vault prolapse. *Am J Obstet Gynecol*. 1997;177:1345–1353.
59. Grimes CL, Quiroz LH, Gutman RE, Shippey S, Cundiff GW, Handa VL. Long-term impact of abdominal sacral colpoperineopexy on symptoms of obstructed defecation. *Female Pelvic Med Reconstr Surg*. 2010;16:234–237.
60. Rooney K, Kenton K, Mueller ER, FitzGerald MP, Brubaker L. Advanced anterior vaginal wall prolapse is highly correlated with apical prolapse. *Am J Obstet Gynecol*. 2006;125:1837–1840.
61. Shippey S, Gutman RE, Quiroz LH, Handa VL. Contemporary approaches to cystocele repair: a survey of AUGS members. *J Reprod Med*. 2008;53:832–836.
62. Shippey SH, Quiroz LH, Sanses TV, Knoepp LR, Cundiff GW, Handa VL. Anatomic outcomes of abdominal sacrocolpopexy with or without paravaginal repair. *Urogynecol J*. 2010;21:279–283.
63. Gilleran JP, Zimmern P. Abdominal mesh sacrocolpopexy for recurrent triple-compartment pelvic organ prolapse. *BJU Int*. 2009;103:1090–1094.
64. Guiahi M, Kenton K, Brubaker L. Sacrocolpopexy without concomitant posterior repair improves posterior compartment defects. *Int Urogynecol J Pelvic Floor Dysfunct*. 2008;19:1267–1270.
65. White AB, Carrick KS, Corton MM, et al. Optimal location and orientation of suture placement in abdominal sacrocolpopexy. *Obstet Gynecol*. 2009;113:1098–1103.
66. Balgobin S, Good MM, Dillon SJ, Corton MM. Lowest colpopexy sacral fixation point alters vaginal axis and cul-de-sac depth. *Am J Obstet Gynecol*. 2013;208:488.e1–488.e6.
67. Abernethy M, Vasquez E, Kenton K, Brubaker L, Mueller E. Where do we place the sacrocolpopexy stitch? a magnetic resonance imaging investigation. *Female Pelvic Med Reconstr Surg*. 2013;19:31–33.
68. Good MM, Abele TA, Balgobin S, et al. Preventing L5-S1 discitis associated with sacrocolpopexy. *Obstet Gynecol*. 2013;121(2 Pt 1):285–290.
69. Shippey S, Sutter E, Belkoff SM, Gutman R, Chen CC. Sacral mesh pullout strength based on suture location for sacrocolpopexy. *Gynecol Obstet Invest*. 2012;74:116–119.
70. Dalwai R, Menon KV, Kumar RJ. Pyogenic diskitis of the L5-S1 disk space following inadvertent placement of a sacrocolpopexy screw. *Int J Gynaecol Obstet*. 2010;111:268–269.
71. Vulliamy P, Berner AM, Farooq MS, Srilekha A. Near-fatal small bowel ischaemia secondary to sacrocolpopexy mesh. *BMJ Case Rep*. 2013; http://dx.doi.org/10.1136/bcr-2012-008179.
72. Elneil S, Cutner AS, Remy M, Leather AT, Toozs-Hobson P, Wise B. Abdominal sacrocolpopexy for vault prolapse without burial of mesh: a case series. *BJOG*. 2005;112:486–489.
73. Rachaneni S, Latthe P. Role of perioperative low dose vaginal oestrogens in improving the outcomes of pelvic organ prolapse surgery. *Med Hypotheses*. 2013;81:1015–1016.
74. Higgins EW, Rao A, Baumann SS, et al. Effect of estrogen replacement on the histologic response to polypropylene mesh implanted in the rabbit vagina model. *Am J Obstet Gynecol*. 2009;201:505.e1–505.e9.
75. Vaccaro CM, Mutema GK, Fellner AN, et al. Histological and cytological effects of vaginal estrogen in women with pelvic organ prolapse: a randomized controlled trial. *Female Pelvic Med Reconstr Surg*. 2013;19:34–39.
76. de Tayrac R, Sentilhes L. Complications of pelvic organ prolapse surgery and methods of prevention. *Int Urogynecol J*. 2013;24:1859–1872.