Contemporary Use and Techniques of Laparoscopic Sacrocolpopexy With or Without Robotic Assistance for Pelvic Organ Prolapse

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The past 4 years have been consequential in the world of surgery to correct pelvic organ prolapse. In 2018, results of a large, multicenter randomized trial demonstrated very disappointing cure rates of traditional native tissue repairs at 5 years or more. In 2019, a vaginal mesh hysteropexy kit was removed from the market by the U.S. Food and Drug Administration only to subsequently demonstrate it provided better cure rates and similar risk profile to vaginal hysterectomy plus native tissue repair in its own 5-year study published in 2021. Meanwhile, the use and techniques of laparoscopic sacrocolpopexy with or without robotic assistance have evolved such that it is commonly adapted to treat all support defects for patients with uterovaginal or posthysterectomy prolapse. This article is intended to provide an overview of the contemporary use and techniques of laparoscopic sacrocolpopexy based on the evidence and our clinical experience.

Pelvic organ prolapse is a common, debilitating problem for which nearly 13% of U.S. women undergo surgical reconstruction.[1] Approximately 300,000 prolapse repair surgeries are performed in this country annually, and this number is expected to increase 50% by 2050 owing to the aging U.S. population.[2] The vast majority of prolapse repairs are performed in a minimally invasive route–either vaginally or laparoscopically. Typically, the vaginal approach involves suture-based, "native tissue" repairs that rely on the patients' connective tissue, which is used as the foundation for restoring anatomic support. The widely used techniques for these vaginal surgeries remain essentially unchanged from their original descriptions.[3,4] However, when scrutinized through rigorous research methods, these traditional native tissue techniques have demonstrated rather poor objective and subjective success rates.[5,6] Use of lightweight polypropylene mesh in the form of a sacrospinous hysteropexy recently demonstrated lower composite failure rates compared with vaginal hysterectomy plus native tissue repair[7] for patients with symptomatic uterovaginal prolapse, but the U.S. Food and Drug Administration removed these products from the market in 2019 before these long-term data became available. This removal of the transvaginal mesh option has resulted in sacrocolpopexy being the predominant approach for mesh-augmented prolapse repair.

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Since the first description of graft-augmented sacrocolpopexy by Lane in 1962,[8] the techniques and use of this procedure have been modified numerous times. In the past 10–15 years, what was once an open abdominal "salvage procedure" reserved mostly for recurrent apical prolapse has evolved into a minimally invasive laparoscopic surgery regularly performed for primary or recurrent prolapse with or without concomitant hysterectomy. This article is intended to provide an overview of the current use and techniques of laparoscopic sacrocolpopexy with and without robotic assistance based on published evidence as well as clinical experience. The contemporary laparoscopic sacrocolpopexy is an operation that can be tailored to correct virtually all support defects for patients with vaginal vault or uterovaginal prolapse without need for concomitant vaginal prolapse repair.

INFORMED CONSENT AND PREOPERATIVE EVALUATION

The consent process for laparoscopic and robotic sacrocolpopexy should include a discussion of the risks, benefits, and typical patient experience for all viable treatment options. An important alternative that should be discussed with certain patients is expectant management with semiannual or annual pelvic organ prolapse quantification (POP-Q)[9] examinations to determine whether there is stability or progression of their prolapse. Many patients with stage I-II uterovaginal prolapse simply need reassurance that the condition is not dangerous and may remain stable over time. On the other hand, demonstrable progression of prolapse as documented on serial POP-Q examinations may influence her decision to consider alternative therapies. Vaginal pessaries should be offered to all patients as a nonsurgical treatment option that is simple, usually effective and can simply be removed with no ramifications if unacceptable to the patient. In terms of surgical options, it is important to discuss long-term success rates and potential risks of sacrocolpopexy as well as native tissue repairs such as sacrospinous ligament suspension and uterosacral ligament suspension. We feel it is important to tailor surgery to the individual patient and recognize that there are clinical situations when native tissue reconstructive or obliterative repairs (such as Le-Fort colpocleisis) are indicated and preferable to sacrocolpopexy.

The comprehensive evaluation for patients with symptomatic pelvic organ prolapse is discussed separately in a previous Clinical Expert Series publication.[10] Therefore, the following discussion will focus mainly on nuances of the evaluation that directly affect surgical planning and preoperative counselling. As would be true leading up to any major surgery, a thorough medical history is required, and certain preoperative tests can be quite helpful. A detailed bladder function history should be taken, and urodynamic studies or cough stress test with prolapse reduction should be performed to rule out potential or occult stress incontinence. For patients with unexplained lower urinary tract symptoms or prior pelvic surgery, preoperative cystoscopy should be considered. For patients with any history of postmenopausal bleeding, evaluation of the uterus through ultrasonography and, when indicated, endometrial biopsy is essential. It is wise to make sure that patients are up to date with colonoscopy screening before having a sacrocolpopexy, because discovery of a colon cancer shortly after mesh has been placed nearby represents a significant missed opportunity—or worse. Obtaining prior operative notes for any pelvic surgery (especially those involving any graft or mesh placement) can be critical to your surgical plan. A preoperative hemoglobin A_{1c} test will identify patients with poorly controlled or previously undiagnosed diabetes, the management of which should be optimized before they receive a permanent mesh implant. It is critical to understand your patient's current sexual function and satisfaction as well as her goal for postoperative sexuality to properly counsel her.

It is important to understand the extent of the prolapse by asking the patient to describe the largest bulge she has ever felt as compared with some object such as an egg, lemon, orange, or grapefruit. Doing so will let you know whether you are witnessing the true extent of her prolapse during the examination. A thorough assessment of each anatomic compartment (ie, anterior, apical and posterior) is performed by asking the patient to cough or Valsalva during bimanual and speculum examinations to derive her POP-Q scores, but those scores are just the start of a comprehensive preoperative examination. A standing examination while the patient coughs or strains usually helps the surgeon understand the full extent of the prolapse, and manual reduction of prolapse while the patient strains in a standing position will provide an appreciation of the physiologic forces that your repair will be up against.

A variety of other physical examination findings should affect the surgical planning and technique. The uterine size and cervical length and width are important factors—especially when the surgical plan involves a supracervical hysterectomy. Occasionally in the presence of severe uterovaginal prolapse, the cervix will be quite enlarged, or edematous. In these cases, a

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supracervical hysterectomy may not be feasible or may lead to surgical failure due to poor integrity of the remaining cervical tissue, so a total hysterectomy may be a better choice. When dealing with an elongated cervix, with proper planning it is usually possible to leave only the distal 2 cm of the cervix in situ. When attempting to diagnose an enterocele, evaluate defecatory dysfunction or anal incontinence, a rectal examination is essential. Sometimes a patient will report having rectal prolapse that you cannot appreciate in the examination room. In these cases, it can be helpful for the patient to take a photo of her rectal prolapse to show you later. It is important to ask about defecation dysfunction and whether they require splinting of the vagina or perineum or both to complete a bowel movement. Referral to a colorectal surgeon, performance of further testing such as dynamic imaging or anorectal physiologic studies, or both may prove useful, because an anterior rectopexy can easily be added to a sacrocolpopexy surgical plan.

An assessment of the patient's estrogen status and pelvic floor muscle strength may lead to a recommendation for preoperative vaginal estrogen use or postoperative physical therapy. We ask our patients who have been using a vaginal pessary to have the pessary removed several days before surgery, which allows any minor discharge or vaginal erosions to resolve before surgery. A recent randomized controlled trial of preoperative mechanical bowel preparation compared with none showed no improvement in surgeon-graded visualization during laparoscopic sacrocolpopexy, so we no longer recommend any standard preoperative bowel preparation.[11]

PATIENT POSITIONING AND EQUIPMENT SETUP

Patients are placed in the low lithotomy position in adjustable boot stirrups (Allen, Yellofin, or PalPro) with knee-high pneumatic compression boots in place and with their buttocks hanging slightly off the end of the operating table. We routinely use 28 degrees of Trendelenburg to keep the intestines safely out of the surgical field. To prevent the patient from sliding while in such steep Trendelenburg, we use disposable foam pads (Pink Pad or generic egg crate foam) on the operating table and surrounding the patient's hands and arms. An indwelling three-way Foley catheter can be useful to keep the bladder empty during dissection while allowing for easy backfilling for identification of the superior margin of the bladder, which is especially useful during posthysterectomy vaginal vault prolapse cases. Alternative ways to backfill the bladder through a traditional Foley catheter are to intermittently remove the catheter from the tubing and squirt water into the bladder using the suction and irrigation device, or to simply hold the Foley collection bag higher than the patient's bladder to let her own urine flow back into the bladder. The Foley balloon can also be useful as a landmark indicating the bladder neck location, which is usually the distal edge of the anterior dissection along the vaginal wall.

Obtaining excellent exposure—especially around the sacral promontory—without tying up accessory ports with retracting instruments such as fan retractors is an essential part of the procedure. In traditional laparoscopic cases, many surgeons will simply place a suture through several epiploic appendages from the rectosigmoid and pull the suture out through the left lower quadrant using a fascial closure needle. The suture is used to retract the rectosigmoid away from the sacral promontory while enabling the surgeon to use all laparoscopic ports for instrumentation. We use a commercially available single-use "T-shaped" device for this same purpose (T'lift). In robotic cases, the left lateral third arm is used to retract the colon using the noncrushing "Tip Up" instrument, and in traditional laparoscopic cases, a suction or bowel retraction device (such as a fan retractor) through one of the ports can also be used to retract the sigmoid.

When the uterus is present, we favor supracervical hysterectomy, because it has been shown to almost eliminate the complication of postoperative mesh exposure. For supracervical hysterectomy with sacrocervicopexy and for uterine preservation (sacrohysteropexy) in traditional laparoscopic procedures, we prefer a disposable lightweight uterine manipulator (eg, HUMI), which allows for easy anteversion and retroversion. For total laparoscopic hysterectomy with sacrocolpopexy, we use a Lucite stent or a uterine manipulator that will delineate the vaginal fornix and maintain pneumoperitoneum after colpotomy.

For posthysterectomy vault prolapse, several types of vaginal stents may be used to delineate the vagina to aid with both dissection and suturing. Reusable and disposable stents made specifically for sacrocolpopexy are available. Our favorites are the Lucite stent (especially for the apical and anterior compartment) and the 16×3.5-cm Breisky retractor (especially for the posterior compartment). For cases involving laparoscopic supracervical hysterectomy, these same instruments are useful during vaginal dissection. In robotic cases involving supracervical hysterectomy, we usually use no vaginal manipulation at all.

Although it is standard practice to use permanent sutures to affix the proximal arm of the Y-mesh to the

anterior longitudinal ligament, choice of suture for attachment of the mesh to the vagina varies. We recommend monofilament sutures for mesh attachment to the vagina, and although we use permanent polytetrafluorethylene sutures, the best evidence indicates that the choice of permanent or absorbable sutures for this step does not influence postoperative mesh or suture exposure.[12]

TROCAR PLACEMENT

For traditional laparoscopic cases, several different configurations of trocar placement may be used, and although this is mostly guided by personal preference and experience, there are a few basic principles that should be kept in mind. The laparoscope is virtually always placed through the umbilical port, and we use a 5-mm 0-degree scope to start the case. Because modern 5-mm laparoscopes with 1080P or 4k cameras and monitors are so superior to older generations, we feel there is no need to use anything more than a 5-mm trocar in the umbilicus. Because the procedure involves dissection and suturing at the sacral promontory, we find it easiest to place the lateral trocars at the level or just below the umbilicus and lateral to the inferior epigastric vessels, typically 8–10 cm lateral to the umbilicus (Fig. 1) The alternative would be lateral trocars placed in the lower quadrants, which would require working backward in a cephalad direction to approach the sacrum. In addition, the patient's upper legs may interfere with the movement of laparoscopic instruments while working at the sacral promontory if the trocars are placed in the lower quadrants. Triangulation is very helpful in getting proper angles for dissection and especially for laparoscopic suturing; therefore, placing the lateral trocars lateral to the inferior epigastric vessels is important to gain this mechanical advantage. We use 5-mm lateral trocars, which accommodates virtually all the instruments we need for this procedure. We personally prefer to use only one larger trocar (11 mm), which we place suprapubically and use for mesh and needle transfer and which is the only one requiring fascial closure for hernia prevention. Alternatively, an 8-mm trocar could be used in this position.

For robotic cases, we use four 8-mm nondisposable trocars placed in a straight line at the level of the umbilicus with one in the umbilicus itself, two spaced evenly on the patient's left side and one on the patient's right side—each approximately 10 cm from the adjacent trocar in the line (Fig. 2). Our assistant port is placed in the right upper quadrant. If the assistant port is larger (11 mm), it is used for mesh and needle transfer, and typically requires fascial closure for hernia prevention. Another possible configuration
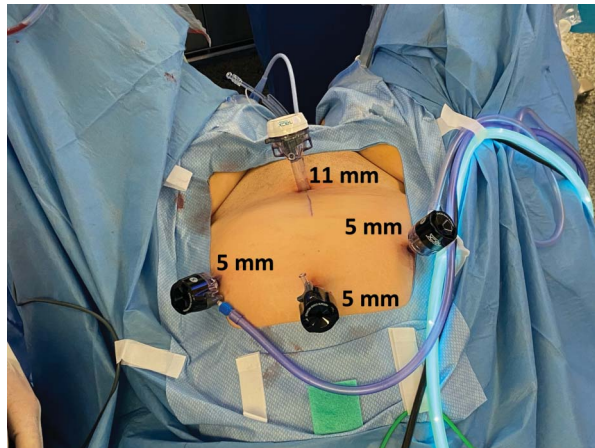
Fig. 1. Typical trocar placement for traditional laparoscopic sacrocolpopexy as seen from the vantage point of the anesthesiologist.
Culligan. Contemporary Laparoscopic Sacrocolpopexy. Obstet Gynecol 2022.

is to use the 12-mm robotic trocar in the umbilicus and either no assistant port or just a 5-mm assistant port. To accomplish this alternative configuration, we use a device that allows for safe placement of all necessary sutures and management of needles all at once (StitchKit). This device can also be inserted through an 8-mm trocar site by removing the robotic trocar after insufflation and placing the device directly through the trocar incision followed by replacement of the trocar. When that technique is employed, the device is removed by pulling it flush with the same 8-mm trocar and pulling them out as a unit together.

PROCEDURAL STEPS

In addition to the descriptions of our surgical techniques below, we have posted three unedited, fully narrated videos demonstrating our techniques of 1) laparoscopic posthysterectomy sacrocolpopexy https://www.youtube.com/watch?v=pt5MmxM6-D4, 2) robotic supracervical hysterectomy and sacrocolpopexy https://www.youtube.com/watch?v=F1dGujj8LYQ&t=1477s, and 3) robotic posthysterectomy https://www.youtube.com/watch?v=ecscXcVLV04&t=1072s sacrocolpopexy.

GENERAL ANATOMIC CONSIDERATIONS

The first step in any sacrocolpopexy procedure is to identify the relevant surgical anatomy, especially at and around the sacral promontory.[13] The aorta typically bifurcates into the left and right common iliac arteries about the level of L4, which is about 5 cm above the sacral promontory. The left common iliac vein can either be visualized or gently palpated with a
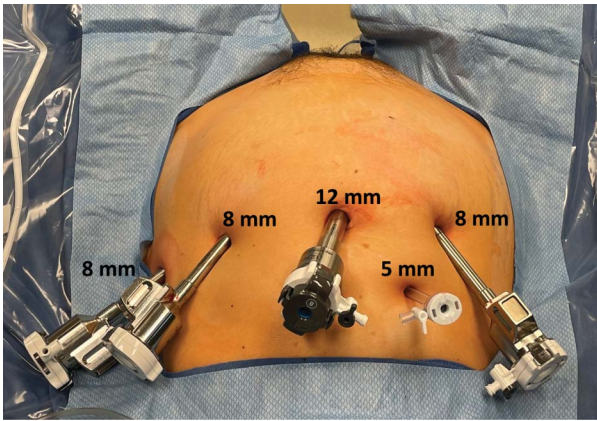
Fig. 2. Typical trocar placement for robotically assisted laparoscopic sacrocolpopexy as seen from the vantage point of the anesthesiologist.

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blunt instrument just medial and inferior to the left common iliac artery. Such gentle manipulation will demonstrate a "waterbed sign," as it depresses with pressure and refills when the instrument is lifted off the tissue. The middle sacral vessels are often seen under the intact peritoneum, although in many cases these vessels are not visualized until the peritoneum has been incised and fatty tissue has been dissected or displaced off the promontory. In addition, the location of the right ureter (laterally) and the rectosigmoid (medially) are identified before initiating any dissection. Of course, numerous anatomic variations can be seen in location of all vital structures including the right ureter, left common iliac vein, middle sacral vessels and sacral venous plexus. Giraudet et al[14] created an educational video that reviews such anatomic variations in a very helpful way.

CONCOMITANT HYSTERECTOMY

For uterovaginal prolapse, concomitant hysterectomy is usually performed even in the face of no uterine pathology, because the hysterectomy simply gets the uterus out of the way making the placement of a Y-shaped mesh logistically easier. Although hysteropexy procedures are certainly feasible there is a paucity of long-term data regarding the subjective and objective success of these procedures. In addition, any future hysterectomy required for cancer or other pathology would be much more challenging in the face of prior mesh sacrohysteropexy. Nevertheless, a large study showed that a significant proportion of patients prefer the idea of uterine preservation even in the face of potentially worse anatomic results, so a thoughtful discussion covering this option is important.[15]

Once the decision to perform a concomitant hysterectomy has been made, the next choice is whether to perform the supracervical or total hysterectomy technique. When supracervical hysterectomy is performed we prefer to place the specimen in a bag and remove it through hand morcellation through the umbilical port site. The main reason to opt for supracervical hysterectomy is its potentially protective effect on mesh exposure rates, whereas the main arguments for the total laparoscopic technique are ease of uterine removal and enhanced ease of anterior compartment correction. In addition, it is important to note that in approximately 0.5% (4 of 786) of cases an occult malignancy will be discovered in the excised supracervical aspect of the uterus or the adnexa.[16] In those cases, subsequent surgery to remove the cervix will be necessary. When an ultralightweight (25 micrograms or less) mesh is used, however, the protective effects of supracervical hysterectomy against mesh exposure may disappear—making this issue a matter of surgeon preference.[17,18]

For robotic cases, we usually perform supracervical or total hysterectomy without any vaginal instrumentation by using the robotic single-tooth tenaculum to manipulate the uterine fundus. For robotic supracervical hysterectomy cases, knowledge of the cervical length allows you to plan the site of amputation. Leaving 1.5–2 cm of cervix intact is optimal, so for the typical postmenopausal uterus the amputation just below the uterine fundus will leave an appropriate amount of cervix. However, for a lengthy cervix you may need to amputate several centimeters below the fundus. Failure to recognize this nuance could result in a well-supported vagina that is literally filled with the cervix.

SACRAL DISSECTION

Many surgeons choose to start the procedure with dissection at the sacral promontory to expose the anterior longitudinal ligament, because of the rare situation when dense adhesions or altered anatomy at the sacrum can prevent successful ligament exposure making a sacrocolpopexy impossible. Electrocautery through monopolar scissors is our preferred energy source for dissection with or without robotic assistance, but it is best to use electrocautery sparingly. We recommend opening the peritoneal layer from just above the sacral promontory down the right paracolic gutter staying medial to the ureter and lateral to the colon all the way down to the medial aspect of the right uterosacral ligament. Doing so should keep the right ureter out of harm's way where it is less visible as it enters the tunnel of the cardinal ligament. After the peritoneal layer is opened, the presacral space will be easier to dissect. It is imperative to identify the left

common iliac vein and stay inferior and to the right of that level to avoid injury to this major vascular structure. Because the middle sacral vessels are adherent to the anterior ligament, there is no risk of injuring these vessels when initially opening the peritoneum. The anterior longitudinal ligament can usually be identified by using laparoscopic or robotic dissectors to gently sweep the fatty tissue overlying the sacral promontory medially, because the area to the right of the middle sacral vessels is usually sufficient for sacral suturing. If the adipose tissue does not sweep off the ligament easily, natural gaps between the "fingers" of fat can usually be exploited to expose the characteristic white ligament. Care should be taken to control even the smallest amount of bleeding, because even small amounts of blood will stain and distort the tissue planes making larger vessels harder to spot. Routine prophylactic cauterization of the middle sacral vessels has been advocated by some surgeons, but doing so may cause damage to adjacent nerves. The hypogastric plexus, which carries autonomic innervation to the pelvic viscera, is located just anterior to the middle sacral vessels, so sparing these vessels probably also spares that plexus and may result in lower rates of de novo constipation.[19]

POSTERIOR DISSECTION

Next, we select an area of peritoneum between the vagina and the rectum through which we gain access to the rectovaginal space. In traditional laparoscopic cases, this is usually done simply by ventral deflection of the vagina with the vaginal probe and gently pulling down on the peritoneum below the vaginal apex. If there is any doubt where the rectum is located, a rectal probe (eg, EEA sizer) can be placed in the rectum and pointed in a dorsal direction while the vaginal probe is still deflecting the vaginal vault ventrally. In robotic cases involving supracervical hysterectomy, we create traction on the cervix through the robotic single-tooth tenaculum and find the areolar tissue and open that space between the two uterosacral ligaments. Once the incision is made in the peritoneum, it is important to stay above (ventral to) any fat that is encountered, because, as has been said, the fat "belongs to the rectum." This dissection can almost always be done bluntly with minimal electrocautery and can usually be taken down all the way to the perineum, which is our typical goal.

ANTERIOR DISSECTION

The next step of the procedure involves dissection between the bladder and the anterior vaginal wall. For posthysterectomy cases, it is often helpful to backfill the bladder with approximately 100–200 mL of fluid, because there is often scarring that obscures the surgical plane. For cases involving a concomitant hysterectomy, this plane is usually pristine and therefore easier to sort out, making backfilling the bladder unnecessary.

In robotic cases that involve either a total hysterectomy or a posthysterectomy prolapse, and for all traditional laparoscopic cases, the vaginal probe is used to delineate the vagina and greatly helps discern the vaginal tissue from the bladder. For robotic cases involving a supracervical hysterectomy, we do not use any vaginal instrumentation, because traction on the cervix through the robotic single-tooth tenaculum provides excellent visualization of the surgical planes as long as the bedside assistant is providing counter traction on the anterior peritoneum. We recommend sharp dissection using monopolar scissors and minimal, judicious use of electrocautery for this step. Proper traction and counter traction are critical. The vaginal wall has a distinctive pearly-white appearance, which should guide the dissection. Any bleeding usually indicates that your dissection is cutting into the vaginal wall; seeing crisscrossing fibers indicates that you are dissecting through the detrusor muscle. Keep in mind that the superior margin of the bladder may even start on the upper-posterior vaginal wall in a posthysterectomy case. We typically use the bladder neck (as determined by the Foley bulb location) as the endpoint of the dissection, but in some cases a less extensive dissection can be adequate. For example, a woman with primarily apical prolapse with an otherwise adequately supported anterior vaginal wall may not need the anterior wall to be taken down that far. If an inadvertent cystotomy is made during the dissection, be sure to use it to guide the rest of your dissection (without making it bigger) before closing it. Such a cystotomy is usually near the bladder dome and well away from the ureteral orifices and should not require abandonment of the surgical plan as long it is repaired well. We recommend a two-layered closure with absorbable suture and thorough cystoscopy to ensure ureteral patency. If an inadvertent vaginotomy is made during your dissection, it should be closed with absorbable sutures and that area should be avoided during mesh fixation if possible.

VAGINAL MESH ATTACHMENT

Mesh Placement in Traditional Laparoscopy

The Y-mesh is prepared by rolling up and securing the sacral tail with a loose suture, which keeps the tail out of the way while suturing to the anterior and posterior vagina. The mesh is laid over the vagina with the bifurcation of the Y-mesh placed at the apex

of the vagina. Interrupted extracorporeal polytetrafluorethylene sutures (Gore-Tex CV-3) are used to affix the mesh to the vagina starting near the vaginal apex and working more distally, which tends to leave the mesh lying flat without folds. The tactile nature of traditional laparoscopy usually allows for self-correction whenever a needle is placed too far through the vaginal wall, because it will hit the vaginal probe. We generally place between 6 and 10 sutures anteriorly depending on the length of a given dissection. Once the needle is cut off the suture and then removed through the suprapubic trocar, the sutures are brought out through the surgeon's lateral port and tied using an extracorporeal knot-tying technique with the open knot pusher. After all the anterior sutures have been placed, any excess mesh is cut away and attention is turned to the posterior mesh extension, where a similar procedure is performed, again starting near the vaginal apex and working more distally toward the perineal body. Another advantage of straight-stick laparoscopic surgery is that the surgeon can place their other hand in the vagina to guide the placement and depth of the more distal posterior wall stiches, including sutures placed in the perineal body.

Mesh Placement in Robotic Surgery

For cases that include a supracervical hysterectomy we do not use any vaginal probe while suturing the mesh to the vagina. The robotic single-tooth tenaculum is used to hold the cervix under traction during posterior suturing. The Y-mesh is cut to the size necessary for the specific repair with the posterior arm usually between 9 and 11 cm and the anterior arm 5–7 cm. The anterior mesh arm is loosely sewn back to the proximal mesh arm to keep it out of the way as the posterior arm is fastened first. First, the distal aspect of the posterior arm is sewn to the perineum with three to four interrupted polytetrafluorethylene sutures (StitchKit-PTFE). The attachment at the perineum would prompt some to classify this technique as a sacrocolpoperineopexy.[20] Next, the remainder of the posterior arm is fixed with similar sutures placed row by row working cephalad. To optimize the visualization of needle bite depth, we recommend tying the knots in between the mesh and the vagina for the posterior wall. Once the entire posterior mesh is secure (usually between 8 and 12 sutures), the single-tooth tenaculum is replaced with the robotic Tip Up grasper, which is placed on the proximal arm of the mesh to create traction for the rest of the case. Ideally, the bifurcation of the Y-mesh will wind up at the level of the cervix where it should be robustly attached completing the posterior mesh suturing.

The anterior space is visualized by placing traction on the proximal aspect of the mesh while the bedside assistant creates counter traction by holding the anterior peritoneum. The interrupted sutures are placed starting proximally and working distally with the knots tied on top of the mesh. Often the anterior dissection plane will be much longer than the ideal size of the anterior compartment (represented by the anterior mesh arm length). When that is the case, the "excess" stretched out vaginal epithelium can be gathered up row by row. This technique allows for correction of virtually any sized anterior defect, thus making any concomitant vaginal prolapse repair unnecessary. Any excess mesh from the anterior arm can be cut away after the entire desired arm is fixed–typically with 8–12 individual sutures.

With either the traditional or robotic approach, the vagina is inspected to identify and remove any sutures that were inadvertently placed through the full thickness of the vaginal epithelium to prevent granulation tissue and possible postoperative mesh exposure. Surgeons who prefer to use two separate pieces of mesh (ie, one anterior and one posterior) rather than a Y-mesh configuration may employ the same techniques described above.

SACRAL ATTACHMENT & TENSIONING

Sacral Suturing With Traditional Laparoscopy

The proximal arm of the mesh is unfurled by cutting the suture holding it in a roll. There are a variety of valid methods for tensioning the mesh at the sacrum, and ours is described here. The vaginal probe is pushed as cephalad as possible and then pulled back about halfway. Then the sacral arm of the mesh is fastened at a point that will mimic the degree of tension using slightly more robust polytetrafluorethylene sutures (Gore-Tex CV-2). Any excess mesh is trimmed away. A 30-degree laparoscope (facing down) is often used to ensure that the suture is placed at the level of S1 and not in the L5-S1 disc space. The suture is placed superficially (about 3 mm or less) so as to avoid suturing into the L5-S1 disc space, which could result in the rare but potentially serious complication of postoperative discitis or osteomyelitis. We first place the suture through the ligament, and then up through the mesh separately. We hold on to the first suture through my lateral port without tying it down, to place the second suture without limiting my visualization of the sacral promontory. Once both sutures have been placed through the ligament and mesh and brought out through the two lateral ports respectively, the sutures are tied down individually using the same extracorporeal knot-tying technique, with an assistant pushing up

on the vaginal stent to take tension off the knot tying. After both sutures have been tied down, an evaluation is made of the tension on the vagina and if needed, a third sacral suture may be placed, although generally only two sutures are required.

Sacral Suturing With Robotic Assistance

The same basic techniques are used except for a few nuances. Because of the lack of true haptic feel associated with robotic suturing, the L5-S1 disc space is avoided by taking advantage of the wristed controls, which make it easy to throw the needles vertically at a slight angle up the slope of the sacrum. Using this strategy means that the bone will always be in position to protect the disc space from the needle. Although horizontally placed sutures result in stronger attachments, these vertically placed bites are more than adequate physiologically.[21]

PERITONEAL CLOSURE

We recommend re-peritonealizing over the mesh on every case to avoid the previously reported risk of an internal intestinal hernia and bowel obstruction, although some authors have found no difference in bowel-related reoperation between patients who did or did not undergo reperitonealization.[22] The technique is similar whether robotic assistance is used or not. We start the process of re-peritonealization before the mesh is attached to the sacrum. A monofilament suture or barbed suture with a loop is used for this step. First a purse string is created in a clockwise fashion tracing the edge of the peritoneal cut edges beginning on the medial aspect of the cul-de-sac and ending just lateral to the mesh itself. We then "jump" the suture over the mesh to complete the purse string in the peritoneum adjacent to where it started and put the needle through the loop on the end of the suture pulling to sinch the peritoneum over the vaginal mesh. The sacral suturing is then performed as described above, and the re-peritonealization is completed by sewing toward the sacrum taking small bites of peritoneal cut edge close to one another so as not to leave gaps. If barbed suture is used, be sure to leave no barbs exposed, and if a monofilament suture is used it can be tied to itself or a laparoscopic re-absorbable clip can be placed on the end (LAPRA-TY).

ASSESSING URINARY TRACT FUNCTION

A cystoscopy should be performed to both rule out unrecognized bladder injury during the dissection or the inadvertent placement of sutures in the bladder, and ureteral patency should be confirmed bilaterally. We perform a postoperative voiding trial on all our patients undergoing laparoscopic sacrocolpopexy, whether or not a concomitant sling or other anti-incontinence operation has been performed during the surgery. Urinary retention or incomplete bladder emptying can occur even when sacrocolpopexy is performed as a stand-alone procedure.

RESULTS

Sexual Function and Satisfaction

Patients with pelvic organ prolapse frequently report sexual dysfunction related to physical discomfort from their bulge, distress over their partners' reaction to their bulge, or both.[23] It is well known that in the absence of de novo dyspareunia, successful pelvic reconstructive surgery often results in improved sexual function and satisfaction.[24,25] De novo dyspareunia rates after sacrocolpopexy have been reported as similar to or lower than those after native tissue repair.[5,26] Among a group of sexually active heterosexual couples, sexual satisfaction improved for both partners after successful robotic-assisted laparoscopic sacrocolpopexy.[27] We believe that avoidance of suture placement in the levator ani muscles and avoidance of mesh over-tensioning are keys to minimizing de novo dyspareunia, but rates between 5% and 8% have been reported with use of ultralight-weight mesh.[28–30]

Bowel Function

Symptomatic pelvic organ prolapse is often associated with bowel symptoms such as splinting to defecate, feelings of incomplete bowel emptying, excessive straining, and constipation,[31,32] and these symptoms typically resolve or significantly improve after reconstructive surgery in general[33] and after open[34,35] as well as laparoscopic and robotic sacrocolpopexy with mesh placement extending to the perineum in particular.[36] When rectal prolapse and defecatory dysfunction presents in combination with symptomatic pelvic organ prolapse, adding a ventral rectopexy to a laparoscopic and robotic sacrocolpopexy has been shown to be safe and effective.[37,38]

Anatomic Correction and Symptomatic Relief of Prolapse

Although there is still no "official" definition of surgical cure after pelvic reconstructive surgery endorsed by medical societies such as the American Urogynecologic Society or the International Urogynecological Association, the most commonly used definition in current clinical trials simultaneously considers both subjective and objective outcome measures such that a patient classified as "cured" by a prolapse repair surgery must meet all of the following criteria: 1) no prolapse beyond the hymen; 2) POP-Q point-C measurement indicating descent less than one third of the total vaginal length; 3) no prolapse symptoms,

based on a negative answer to the prolapse-specific question on bulge symptoms (PFDI-20 [Pelvic Floor Distress Inventory-20][39] question 3); and 4) no postoperative need for repeat prolapse surgery or use of a pessary.

Laparoscopic sacrocolpopexy with or without robotic assistance has demonstrated outstanding long-term (5 years or more) cure rates approaching 90% based on the strict criteria above,[18,40] These data are especially encouraging and meaningful when one considers that the best information we have to date regarding native tissue vaginal repairs pegs the 5 years or more cure rates at 30–40%.[6] Although relatively few women in this trial went on to have reoperations, this fact should not be used to minimize the importance of the many other symptomatic prolapse recurrences reported. On the contrary, it seems likely that these trial patients who did not choose to go through subsequent repairs made those choices owing to skepticism regarding better future outcomes. Moreover, the only vaginal surgery with reported long-term cure rates comparable with those for laparoscopic and robotic sacrocolpopexy is the vaginal mesh hysteropexy, which was removed from the market by the U.S. Food and Drug Administration in 2019.[7] We agree with the authors' conclusion from that study, which states that the vaginal mesh hysteropexy procedure should be made available to patients. However, unless that happens, the laparoscopic sacrocolpopexy with or without robotic assistance will remain the minimally invasive approach to prolapse repair with the best reported long-term cure rates as defined by the latest composite definitions. Whether performed by traditional "straight stick" laparoscopy or with robotic assistance, sacrocolpopexy results after an adequate learning curve are similar.[41] Indeed, laparoscopic sacrocolpopexy performed by bringing the anterior mesh arm to the level of the bladder neck and the posterior mesh arm to the perineum is an effective and reasonable minimally invasive surgical approach that can be adapted to correct virtually any configuration of pelvic organ prolapse that includes apical descent.

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