

Minimally Invasive Approaches To Pelvic Reconstructive Surgery

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The term “minimally invasive surgery” generally represents the effort to reduce the impact of surgery on the patient, both in terms of incision size and location, as well as patient discomfort and recovery of normal health status. The recognition of the importance of these characteristics has pervaded all aspects of surgery – generally speaking, there is widespread acceptance of the role of minimization of incision size, use of self-retaining retractors, and other measures to improve the patients’ overall experience and recovery, and these might be considered efforts to reduce the invasiveness of surgery in general. For the purposes of this article, two main categories of surgery will be considered: laparoscopic (and robotic) surgery, and trocar-based surgical kits and techniques.

The advent of laparoscopy for gynecologic surgery was greeted with much enthusiasm; the potential advantages in decreased postoperative pain¹, rapid recuperation², decreased adhesion formation³ and preferable cosmetic result led to a rapid increase in the rate of tubal ligation. The utility of the laparoscope as a diagnostic tool was quickly realized, and it enjoyed popularity in the diagnosis and treatment of chronic pelvic pain and endometriosis, as well as in surgical sterilization.

As the tool of the laparoscope has been applied to more advanced surgical procedures, these advantages to the patient have remained significant, and other advantages were realized. The microscopic

visualization of the laparoscope has improved identification and avoidance of the vascular structures that have complicated retropubic procedures. Additionally, the pneumoperitoneum used during laparoscopy provided some measure of tamponade, again reducing the nuisance of venous oozing during the retropubic dissections. Finally, patient satisfaction with the laparoscopic approach to urogynecologic procedures is favorable.⁴

LAPAROSCOPIC TECHNIQUES

Laparoscopic Burch colposuspension procedure

The retropubic colposuspension, along with suburethral slings, has become, to many, the gold standard for treatment of urodynamic stress incontinence due to bladder neck hypermobility without intrinsic sphincter deficiency.⁵ The Burch procedure, or more accurately, the Tanagho modification of the Burch procedure,⁶ was performed laparoscopically and described by Vancaille in 1991⁷, with publication of a case series soon afterwards.^{8,9} The laparoscopic advantages of visualization, hemostasis, and quick recovery for the generally healthy population helped to make this a popular procedure for adaptation to the laparoscopic approach.

Technique:

Similar to the open technique, the laparoscopic Burch procedure involves retropubic dissection, clearing of the paraurethral and paravesical fascia, placement of two

sutures on each side (one at the urethrovesical junction, the other at the midurethra, at least 2 cm lateral to the urethra itself), which are then suspended from Cooper’s ligament ipsilaterally (Figure 1). Suture placement in the paraurethral tissue is facilitated by elevating the tissue with the surgeon’s finger in the vagina. Practitioners vary widely in their techniques of assessing the right amount of bladder neck elevation; however, the data have shown that correction of hypermobility is a requirement for successful outcome.¹⁰ Overcorrection, though, can lead to voiding dysfunction; therefore, suture bridges are left to prevent overcorrection. It is also advisable to close any peritoneal incision to prevent incarceration of bowel within these suture bridges.

With the popularity of minimally-invasive slings, the popularity of the Burch procedure has waned; the skillset required and operative time tend to favor the newer generations of slings, and success rates of these slings are at least as high or higher.¹¹ Interest in the Burch procedure was regenerated, to some degree, by the CARE trial, in which patients undergoing open sacrocolpopexy for vaginal vault prolapse were randomized to receive, or not receive, a concomitant Burch procedure, regardless of preoperative urodynamic findings.¹² Patients who underwent the Burch procedure were half as likely to report postoperative stress incontinence as their counterparts. Many practitioners who have developed

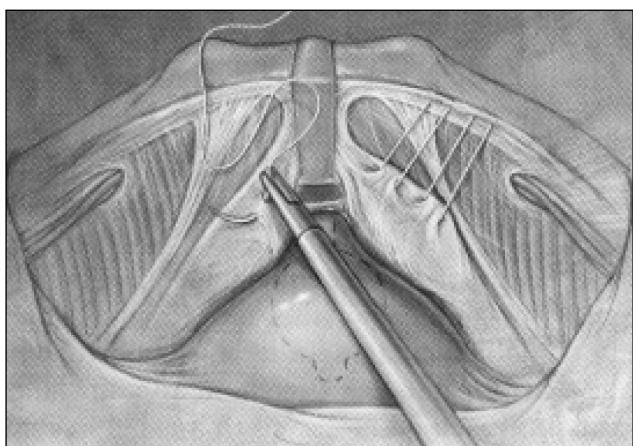


Figure 1. Burch Colposuspension

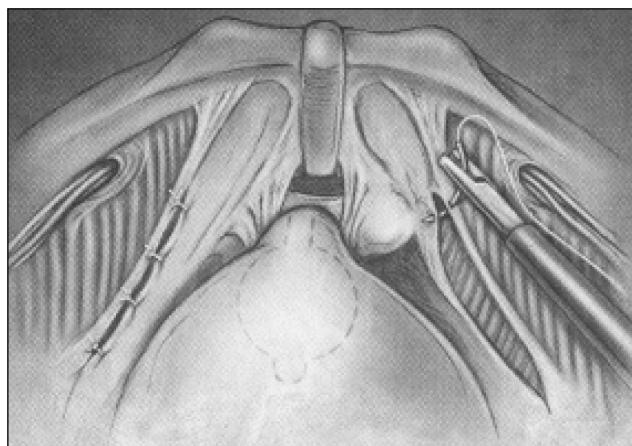


Figure 2. Paravaginal Defect Repair

skills in laparoscopic sacrocolpopexy are adding laparoscopic colposuspension in light of these findings.

Laparoscopic repair of a cystocele paravaginal defect

Although the traditional repair of cystocele (colporrhaphy) has involved the central plication of the pubocervical fascia, the idea that anterior compartment defects can be lateral (paravaginal), as well as central, was first published nearly a century ago.¹³ (Figure 2) As the surgical reattachment of pubocervical fascia to the arcus tendineus of the fasciae pelvis (or “white line” of the pelvic sidewall) is more challenging than simple colporrhaphy, this idea lay dormant until the 1970s, when Richardson postulated that the majority of cystoceles are a result of this lateral disruption.¹⁴ More recent anatomic studies have confirmed that lateral defects are usually present in cases of anterior compartment prolapse and bladder neck hypermobility.¹⁵ Needless to say, a central repair for a lateral defect may reasonably be expected to yield suboptimal success rates.

Technique:

The laparoscopic paravaginal repair, as with the Burch procedure, starts with retrograde filling of the bladder, supravesical peritoneal incision, and dissection of the retropubic space. As the goal is the reattachment along the full length of arcus tendineus along the pelvic sidewall, the dissection must be carried out more laterally than is required for the Burch. For this reason, the peritoneal incision is usually taken beyond the medial umbilical folds; care must be taken to avoid injury to the inferior epigastric vessels. Similarly, identification and protection of the obturator neurovascular bundles is crucial.

After the paravesical fascia is cleared with gentle dissection, a series of permanent sutures is used to reattach the fascia to the obturator internus muscle on each side. The appearance of the arcus tendineus along the sidewall may be variable; one study showed that the condensation of fibers known as the “white line” are often avulsed and thus attached to the paravaginal fascia, rather than intact along the pelvic sidewall.¹⁵ Thus the surgeon may not always have the clear visual cue along the sidewall. Whether or not the arcus is readily visible, its original location between the ischial spine and the

inferior edge of the pubic ramus can be located by palpation under laparoscopic observation. The surgeon will appreciate the fact that, in this approach, the tissues being sutured together are adjacent; in the vaginal paravaginal repair, the vaginal sutures must be placed with the tissue everted, and thus distant from the targeted area of reattachment.

Laparoscopic repair of vault prolapse – Uterosacral ligament suspension

While uterosacral ligament vault suspension has been well described vaginally;¹⁶ the abdominal or laparoscopic approaches are also feasible. However approached, the technique involves identifying the intact remnants of the uterosacral ligaments, at or above the level of the ischial spines, which are then sutured to the ipsilateral aspects of the posterior and anterior fascia of the vaginal vault. It should be noted that, in the case of fascial attenuation, an enterocele sac is likely to be found between these intact anterior and posterior fasciae. The vaginal approach can be made difficult by the challenge of identifying the proximal ligament remnants. In addition, the suture, if permanent (as many advise), must be tied extraluminally, which can be difficult; alternatively, an absorbable suture can be tied within the vaginal lumen. The possibility of ureteral compromise, reported to be as high as 11% with the vaginal approach,¹⁷ necessitates the use of intraoperative cystoscopy. The visualization of the ureters throughout their pelvic course that laparoscopy can provide may be an additional benefit.

Technique:

Laparoscopic uterosacral vault suspension can be performed at the time of hysterectomy, or remotely from hysterectomy, in the case of vaginal vault prolapse. After the ureters and the rectum are identified, the uterosacral ligaments are identified at the level of the ischial spines. Permanent suture is then brought through the ligaments at this level; tensiometry studies have demonstrated that laparoscopically-placed sutures in the uterosac-

ral ligaments have as much tensile strength as vaginally-placed sutures.¹⁸ With the proximal uterosacral ligament thus captured, the sutures are then brought ipsilaterally through the full thickness of the posterior and anterior vaginal walls (excluding epithelium) at the cuff. (Figure 3) The attenuated enterocele sac that may lie at the apex, between anterior and posterior vaginal wall fasciae, can often be visualized with the use of the vaginal probe. Some surgeons advocate the excision of this attenuated tissue sac; whether or not it is removed, the supporting sutures should be placed beyond it, on the intact fasciae. Advocates of this procedure point out that it is restorative of the original anatomic support and vaginal axis.

Sacrocolpopexy

The uterosacral vault suspension procedure described relies on the presence and identification of useful uterosacral remnants; it also depends on vaginal sutures at the vault apex for long-term success. In addition, for the reasons outlined above, the vaginal apex, in the presence of an enterocele, may represent the most attenuated segment of the entire vagina. Vaginal techniques of vault suspension, including the vaginal version of the uterosacral vault suspension, as well as the sacrospinous ligament fixation, may be susceptible to the same vulnerability. For these reasons, many surgeons prefer the sacrocolpopexy using permanent materials. Although not anatomic in the strictest sense, it has been shown to yield a vaginal axis that is closer to normal than that found after vaginal sacrospinous liga-

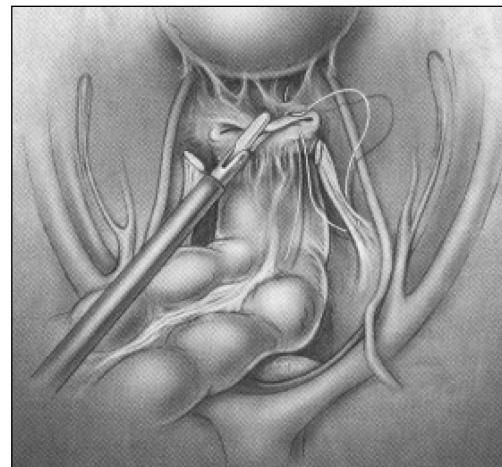


Figure 3. Uterosacral Ligament Suspension.

ment fixation.¹⁹ It also permits the placement of multiple suture points along the anterior and posterior vaginal walls, distributing tension over a wider area and decreasing the likelihood of suture pull-out. In its abdominal version, it has been demonstrated to have a remarkably low recurrence rate over the long term.²⁰

Technique:

A peritoneal incision over the sacral promontory is made and the underlying anterior longitudinal ligament of the sacrum is visualized. Laparoscopically, the pneumoperitoneum facilitates dissection of the retroperitoneal areolar tissue, and the microscopic visualization allows easier identification of the sacral vessels which, if injured, retract into the sacrum and results in catastrophic bleeding. It should be noted, however, that the left common iliac vein, which lies just below and inferior to its arterial counterpart, can be compressed by the pneumoperitoneum, and therefore inadvertently injured. For this reason, the dissection over the sacral promontory should be kept slightly to the right of the midline. This incision is carried down into the pelvis, remaining slightly to the right of midline (to avoid mesenteric vasculature) but well medial to the right ureter. This incision allows for the retroperitonealization of the mesh after the suspension.

After the vaginal vault is prepared by dissecting peritoneum off of the anterior and posterior aspects (and the development of the vesicovaginal and rectovaginal spaces, respectively), a Y-shaped graft is affixed to both sides of the vaginal vault. At that point, the main arm of the Y is affixed directly to the anterior longitudinal ligament of the sacrum, with

a series of permanent sutures. (Figure 4) Care should be taken to avoid the middle sacral vessels, and tools to control for presacral bleeding should always be available. The proximal ends of the graft are then affixed to the sacrum, with care taken to avoid tension. After excess graft is trimmed, the peritoneum is closed over the graft to reduce the likelihood of bowel incarceration or adhesion.

Although long-term or prospective data regarding the effectiveness of the laparoscopic approach is limited, several reports support the benefits of minimally invasive techniques in the execution of this form of vaginal support. As has been demonstrated in many other arenas, laparoscopic sacrocolpopexy in the hands of trained surgeons yields similar efficacy while enhancing hemostasis and reducing postoperative pain and hospitalization.^{21 22 23} Here, as before, the principle that laparoscopy is a means of access, and that the steps of the procedures should be identical to that of the open technique, are of utmost importance.

OTHER RECONSTRUCTIVE PROCEDURES

Rectocele

Variations on the above procedures have been performed and described for the treatment of similar conditions. Laparoscopic rectocele repair has been described, in a procedure which involves the extended dissection of the rectovaginal septum all the way to the perineal body, and either plicating the levator musculature,²⁴ or suturing mesh material in place.²⁵ In principle, this approach to mesh-based repair of the posterior wall may enhance outcomes by eliminating vaginal incisions, which are thought to be contributory in the development of problematic mesh erosion.

Uterine Preservation

In addition, several studies have called into question the practice of routine extirpation of prolapsed uteri.^{26,27} Patients interested in uterine preservation value the availability of this choice, and the elimination of the hysterectomy decreases blood loss, hospitalization, and other complications²⁸. Clearly, patients must understand that

future pregnancy and delivery may have deleterious effects on the repair, cervical surveillance remains necessary, and hysterectomy may be needed in the future. This option continues to be valued by some women and some practitioners. Both the uterosacral ligament suspension, and the sacrocolpopexy using mesh, can be performed for the treatment of uterine prolapse among women who desire uterine conservation; the techniques are very similar to those described for vault prolapse above.

Robotics in Pelvic Reconstructive Surgery

The da Vinci robotic surgical platform (Intuitive Surgical, Inc., Sunnyvale, CA) represents a significant technical advancement in the instrumentation for laparoscopic surgery. Sitting at a console, the surgeon uses controls to operate a set of robotic arms fitted with specialized instruments. The main advantages include motion scaling (converting large movements of the surgeon to very fine movements of the instruments), instruments with an additional degree of motion (known as an endo-wrist), and the enhancement of dexterity and psychomotor performance (through tremor-stabilizing algorithms). The da Vinci system also uses binocular, 3-dimensional video, enhancing depth perception. The performance of these systems in the training of residents is in the early stages. One study demonstrated a steeper (that is, more rapid) learning curve, among both experienced and inexperienced surgeons, in the performance of drills using a robotic system.²⁹ Another study demonstrated that laparoscopic drills were completed more quickly with the robotic system compared to traditional laparoscopy, and that novice surgeons on the robot performed as quickly, and in some cases more quickly, than expert surgeons with traditional laparoscopy.³⁰ The continued refinement of these systems may redress some of the deficiencies in laparoscopic training by improving skill acquisition. The robotic platform will likely increase the number of surgeons with minimally-invasive skills to treat pelvic floor defects.

Most of the literature regarding the usefulness of the robotic platform addresses its use in Urology, where its application to minimally invasive radical prostatectomy has generated significant interest. In terms of Gynecologic Oncology, the introduction of

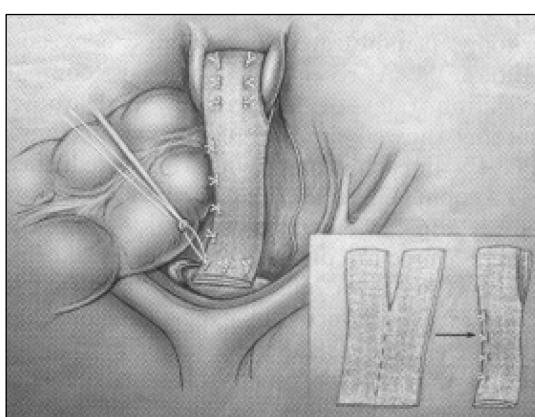


Figure 4. Abdominal Sacrocolpopexy

robotics resulted in significantly lower blood loss and postoperative hospitalization, while lymph node yield remained similar.³¹ Early literature supporting the use of robotics in pelvic reconstructive surgery shows promising results in applications such as sacrocolpopexy³²

TROCAR-BASED MESH REPAIRS

The trocar - based Tension-free Vaginal Tape suburethral sling procedure heralded the arrival of a new paradigm of reconstructive surgery, and the principles underlying its effectiveness continue to be applied to new pelvic reconstructive techniques. There are three important ways in which the TVT® (Gynecare Ethicon, Sommerville, NJ) differs from the slings that preceded it: midurethral placement (rather than at the bladder neck), trocar-based delivery, performed blindly and with minimal dissection, and self-retaining mesh that required no anchoring or fixation. A variety of tensioning techniques exist, with the key provision that, at rest, the tape should exert no tension on the underside of the urethra. The blind passage of trocars through the retropubic space requires advanced anatomic understanding and confidence on the part of the surgeon, and is beset with a certain incidence of bladder perforation and, much less commonly, bowel and vascular injury.

Taking several principles of the TVT, de Leval introduced the transobturator sling in 2003. It is similar to the TVT in its trocar-based, midurethral placement, and self-retaining mesh materials. However, this technique passes the trocar through the obturator membrane avoiding entry into the true pelvis. This lateral approach seeks to reduce the likelihood of injury to pelvic organs or vasculature. Indeed, a meta-analysis of randomized trials between the techniques found similar success rates, with an apparent reduction in complications with the obturator approach.³³ The success of the obturator approach in cases of intrinsic sphincter deficiency has yet to be fully described, but several authors have reported lower success rates of this technique among these patients.

Finally, the concept of self-retaining mesh prostheses implanted with trocars performed for incontinence was brought to repair of prolapse. The introduction of trocar-based mesh kits- the intravaginal slingplasty (IVS™ Tyco Corp.), the

Apogee/Perigee™ (American Medical Systems, Minnetonka, MN), and the Avaulta™ (Bard, Covington, GA) and Prolift™ (Ethicon, Cincinnati, OH) are such systems. These devices, although with some differences, share the fundamental principles of self-retaining, tension-free mesh, introduced vaginally and affixed to a variety of pelvic anatomic landmarks, to support the appropriate compartments of the vagina. These techniques are discussed in greater detail elsewhere in this issue.

DISCUSSION

At its best, laparoscopic pelvic floor defect repair represents an alternative approach to performing established procedures; laparoscopy can offer benefits to the surgeon (improved visualization, access for multiple procedures) and patient (decreased pain, scar formation, recuperation, and improved cosmesis). Many practitioners prefer the term "minimal access surgery" to the more prevalent "minimally-invasive surgery," as, ideally, only the route of access, not the procedure itself, is changed. At its worst, laparoscopy invites surgeons to take these established procedures and to modify them, to eliminate steps and cut corners, to the point where it bears only a tenuous relationship to the original. As such, some experts have challenged laparoscopists that their patients should be consented for "experimental" surgery.³⁴ Similarly, dialogue and debate about the merits and concerns of trocar-based mesh prolapsed repair kits continue. While Gynecology will benefit from further investigations of outcomes of minimally invasive pelvic reconstruction, there is evidence already that these techniques are feasible and offer options in the treatment of patients with pelvic floor disorders.

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Disclosure of Financial Interests

The author has no financial interests to disclose.

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