10 Robotic/Laparoscopic Female Pelvic Reconstructive Surgery

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Introduction

As the life expectancy of our population continues to increase, so does the prevalence of medical conditions associated with advancements of age. Pelvic organ prolapse (POP) is a common condition associated with aging, menopause and prior pregnancy, and delivery. Surgical repair of POP is currently the most common type of inpatient procedure performed in women older than 70 years [1], and there is no doubt that the incidence of procedures for this condition will continue to increase. As we attempt to improve patient awareness of POP and options in treatment of symptomatic prolapse, we in turn strive to optimize surgical treatment techniques.

The abdominal sacrocolpopexy is regarded as the "gold standard" procedure for correcting defects of the vaginal vault [2] and for some patients, this open, abdominal technique continues to be an appropriate choice for prolapse repair. In many patients, however, minimally invasive routes of this and other gynecologic procedures are preferred [3, 4], and offer advantages both for the patient and the surgeon. Minimally invasive sacrocolpopexy has been compared with the abdominal approach in various studies and has proven to be as efficacious and safe, with the added benefit of decreased morbidity [5–7]. More recently, two level 1 studies have been published comparing abdominal sacrocolpopexy with a minimally invasive approach. Both trials reveal comparative outcomes between the groups and illustrate that the minimally invasive approach is associated with decreased morbidity, less blood loss, shorter length of stay, and overall decreased recovery time [8, 9]. These data support the use of minimally invasive surgical approaches to sacrocolpopexy and other POP procedures.

With minimally invasive surgery comes a unique set of perioperative considerations, counseling topics and both intraoperative and postoperative complications. Surgeons should be aware of these unique components of minimally invasive surgery and should understand ways to minimize potential obstacles wherever possible. This chapter aims to highlight the potential perioperative complications unique to minimally invasive female pelvic surgery and to discuss how to effectively handle these problems, should they arise.

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Preoperative Considerations

When determining surgical candidacy for minimally invasive reconstructive pelvic surgery, the surgeon must gather critical information during the office evaluation. It is imperative to focus the history and physical exam around factors that could increase the risk of complications unique to minimally invasive surgery. When considering a laparoscopic or robotic approach, the medical history should include questions about the patient's exercise tolerance, smoking history, presence of cardiopulmonary or chronic renal conditions, and history of prior pelvic surgeries. The surgeon should have a good understanding of the hemodynamic and metabolic effects of intra-abdominal CO_2 insufflation on individuals with these conditions. Potential contraindications to laparoscopic or robotic surgery such as increase in intracranial pressure or baseline hypovolemic state should be contemplated, especially when the operative time may be prolonged. Patients with pulmonary compromise should be particularly counseled on possible conversion to laparotomy if the degree of physiologic strain, such as impairment of pulmonary functional residual capacity, becomes intolerable to the patient during surgery [10]. It is well documented that patients benefit from smoking cessation prior to surgery and encouraging patients to stop smoking within 8 weeks of surgery can be beneficial. Studies demonstrate improvements in respiratory function and lower risks of postoperative atelectasis and aspiration pneumonia, known results of the inability to tolerate pneumoperitoneum or steep Trendelenberg positioning [11]. While research indicates that pulmonary complications after laparoscopy may be lower than those associated with laparotomy, surgeons should be aware of the specific risks in patients with cardiopulmonary comorbidities, such as COPD. Pulmonary complication risk is also found to correlate positively with older age and longer operative time [12]. This should be taken into consideration when deciding route of pelvic reconstructive surgery.

The physical exam should include assessment of abdominal scars and the presence of any abdominal hernias, particularly if a patient has had multiple prior abdominal surgeries. This will allow for anticipation of potential difficulties with port placement and pelvic adhesive disease when planning a minimally invasive surgical approach. Particular attention should be paid to umbilical hernia as the umbilicus is often utilized as a port site during minimally invasive surgery. Additionally, a bimanual pelvic evaluation to assess uterine mobility and size is necessary. One should attempt to palpate the width of the lower uterine segment (LUS) at its junction with the cervix and assess degree of movement of this segment toward the contralateral pelvic sidewall. In general, lateral mobility of 2 cm or more on each side predicts adequate access to uterine vessels laparoscopically. The presence of obstructing fibroids or pelvic adhesions should also be considered, as these characteristics can limit uterine mobility and preclude successful minimally invasive pelvic surgery. Placing cephalad pressure on the LUS and attempting to elevate the uterus out of the lower pelvis can help with understanding of circumferential space that is present. This technique may be inhibited by patient body habitus. At times, pelvic imaging may be necessary to adequately assess uterine size and other pelvic pathology that may make laparoscopy more difficult.

Obesity itself should not preclude minimally invasive surgery; however, it can make a laparoscopic or robotic approach to pelvic surgery more challenging due to impact of this condition on both respiratory and gastrointestinal mechanics. Obese patients, particularly with a BMI >40, are prone to poor gas exchange and delayed gastric emptying, increasing risk of impaired respiratory function and aspiration during and after surgery. Obesity also is commonly associated with increased central adiposity, which can preclude optimal patient positioning, trocar placement and visualization intraoperatively [13, 14]. It is imperative to consider these risk factors when counseling patients on minimally invasive surgery and extra time should be allotted perioperatively to ensure optimization of patient positioning.

The surgeon should inquire about any known anomalies of pelvic anatomy. Anatomic variances such as a horseshoe kidney, transplant kidney, or any sacral anomalies could make the minimally invasive sacrocolpopexy more difficult or contraindicated. Knowledge of these potential structural alterations should prompt adequate imaging to obtain a clearer understanding of any variations or abnormalities in pelvic anatomy. Surgeons can then plan for any required modifications in instrument placement or surgical technique when performing pelvic surgery.

Screening for stress incontinence is pertinent when performing any prolapse procedure and if present, discussion of a possible concomitant anti-incontinence procedure is needed. The surgeon should take into account the risks and benefits of added operative time with concomitant procedures, and potential complications this could pose. Conversely, without the presence of stress incontinence, there still should be a discussion regarding the possibility of de novo stress incontinence post-prolapse repair. Ideally, patients should be screened for occult stress incontinence with prolapse reduction preoperatively to allow for proper counseling and surgical planning. Management of expectations is critical and patients should be made aware that midurethral sling placement at the time of minimally invasive sacrocolpopexy may be associated with lower incontinence cure rates, when compared to sling surgery alone [15].

Traditionally, preoperative mechanical bowel preparation (MBP) has been used as a way to enhance visualization of the surgical field and improve intraoperative bowel handling. In theory, this practice leads to a decreased incidence of bowel injury and lowers minimally invasive operative times. More specifically, bowel preparation can facilitate sacral visualization during minimally invasive sacrocolpopexy. Recently, there has been evidence in the literature refuting the necessity of mechanical bowel preparation in minimally invasive surgery in gynecology [16, 17]. In a recent systematic review of high-quality trials across surgical specialties, there were no or few benefits of MBP or rectal enemas and no negative effects on perioperative outcomes were reported [18]. These data should prompt surgeons to contemplate the risk and benefit of MBP when performing minimally invasive prolapse surgery. In surgical procedures where this practice seems beneficial, preparations using Magnesium Citrate or Miralax combined with 64 oz. of Gatorade appear to be the best tolerated [17].

Patient Positioning and Surgical Setup

Intraoperatively, there are many techniques that can be adopted to allow a surgeon to decrease risk for complications when performing minimally invasive pelvic reconstructive surgery. It is critical to maintain constant communication between the anesthesia and surgical teams when choosing the most appropriate operating room set up, as each case may require adaptations to the arrangement of room layout, instrument choice, and other ergonomic considerations. For both laparoscopic and robotic-assisted prolapse repair, proper patient positioning is imperative to sustain optimal surgical exposure and prevent neuromuscular compromise. One obvious concern with these surgical techniques is cephalad sliding of the patient on the operating table during steep Trendelenburg positioning. This can result in skin breakdown and neuropathic injuries, as well as incisional extensions and formation of hernias through port sites due to the overstretching caused by incidental changes in patient position. Nerve injury is increased in obese patients, who most commonly suffer from ulnar and sciatic neuropathies [14]. The surgeon should ensure proper corporeal padding of both upper and lower extremities. The knees should be flexed at a maximum angle of 60° when patients are placed in dorsal lithotomy position. Any greater flexion increases the risk for femoral nerve compression. Arms should be tucked at the patient's side and all pressure points should be adequately protected. Leaving the arms extended or the use of shoulder blocks can increase the risk of brachial plexus injury and these practices should be avoided [19]. Recent evidence illustrates that use of anti-skid materials such as egg crates, surgical beanbags, or gel pads minimizes risk of shifting and therefore decreases potential for nerve stretch injuries, even in patients with a BMI >30 [20].

After the anti-skid material is placed on the operating table, the patient should be placed directly on this material without intervening bedsheets. This direct contact allows for optimal drag coefficient to keep the patient from slipping and is very effective for steep Trenedelenburg positioning during pelvic reconstructive surgery.

The risk of facial trauma and corneal abrasions should also be considered, especially when performing robotic surgery. The patient's face can be in close proximity to the robotic camera system and instruments, especially when port sites are placed superior to the umbilicus or when using a 30° down scope in steep Trendelenburg position. At these instances, the robotic camera system may only be a few centimeters away from the face and facemasks or adhesive eye shields should be used to protect from facial trauma. Direct trauma is known to be the cause of up to 20% of corneal abrasions, and most are thought to be due to lagopthalmos or failure of complete eyelid closure [21]. To protect this perioperative complication, the eyes can be taped closed after induction of anesthesia. It is important to consider these potential adverse events and discuss ways to minimize risk with the anesthesia team.

Whether performing laparoscopy or robotic-assisted pelvic surgery, the utilization of Trendelenburg positioning is traditionally noted to be essential to achieve adequate exposure. Compared with traditional laparoscopy, robotic surgery has been associated with the use of more pronounced Trendelenburg positioning. Although there is no consensus in the medical literature as to the appropriate amount of Trendelenburg used in pelvic surgery, experts have routinely called for "steep" Trendelenburg positioning, usually categorized as 25°–45°. While this has long been the routine positioning of patients undergoing robotic pelvic surgery, recent data have suggested that gynecologic surgeries can be effectively performed without use of this steep angle positioning, which is often times associated with increased morbidity, especially in the elderly or obese populations. In a recent article by Ghomi and coworkers, 20 women underwent robotic-assisted gynecologic surgery for benign disease. The procedures included total and supracervical hysterectomy as well as sacrocolpopexy. Surgeons were blinded to the degree of Trendelenburg used; however, they were instructed to choose the degree of positioning which would allow them to obtain adequate exposure of the surgical field. Degree of Trendelenburg was measured at the end of each case and results revealed the mean Trendelenburg position used was 16.4° and no patient was placed further than 24°. There were no incidences of conversion, no perioperative complications and average BMI was 28.5, while median console time was 87.5 min [22]. Though the only study of its kind, these data defy the practice of routine adherence to steep Trendelenburg positioning if not absolutely necessary and surgeons should take care to individualize patient positioning for each case in order to minimize complications associated with a considerable degree of Trendelenburg placement. Extra caution should be taken in any patient with retinal disease or prior retinal surgery, as Trendelenburg positioning has been associated with retinal complications in some reports.

Having a clear understanding of abdominal wall anatomy is crucial for proper port site placement, in order to avoid vessel injury during this portion of the case. Both robotic and laparoscopic ports are generally placed in a W configuration, a minimum length of 10 cm apart, to allow for adequate space and optimal utilization of all ports and to minimize arm collisions. To optimize visualization of the sacral promontory, the camera port should be placed above the umbilicus if the distance from the umbilicus to the pubic symphysis is less than 15 cm. The use of a 30° (up) robotic camera to place the four additional ports is oftentimes helpful to adequately evaluate the pelvis for any intrusive adhesions and also to position ports properly and ensure avoidance of epigastric vessels. Port site bleeding is noted to occur at an incidence of about 0.7% [23], and the origin is most commonly due to perforation of the inferior epigastric artery. If perforation does occur, it is best to leave the offending trocar in place to denote the location of the injured vessel. If each end of the transected vessel can be identified, cauterization of both ends using bipolar cautery should be attempted. If this is not successful, the method of tamponade using a foley catheter can be used. A size 10 or 12 French Foley catheter should be introduced through the 5-mm trocar and inflated with approximately 10–15 mL of sterile water. The trocar is removed only once the balloon has been inflated, and then traction should be applied to allow the balloon to tamponade the port site [24]. Clamping the catheter on steady traction with use of an umbilical clamp or hemostat is helpful and this can be left in position postoperatively if necessary, until hemostasis is achieved. If neither of these methods will stop port site bleeding, interrupted 0-vicryl sutures can be placed into the abdominal wall using a CT or CT-1 needle. One suture should be placed at each side of the trocar site and tied externally. These sutures can be removed after 12–24 h of observation, and the trocar should be left in place during this time.

The use of an 8-mm accessory port is our preference, as the literature reveals a smaller accessory port results in less postoperative pain and decreased risk of port site hernias when compared to larger accessory ports. In a survey conducted by the American Association of Gynecologic Laparoscopists, port site hernias were found to occur in port sites 10 mm or larger in 86% of cases, while those 8 mm or smaller were associated with only 3% of port site hernias reported [25]. More recently, Paraiso and coworkers discussed the notion of lower postoperative pain with use of smaller ports when comparing postoperative pain scores in patients undergoing robotic and laparoscopic prolapse surgery. Those undergoing laparoscopy endured fewer and smaller trocar incision sites, which correlated with lower postoperative pain scores [26]. Given this, we routinely use the smallest size ports necessary when performing minimally invasive pelvic organ prolapse surgery. For robotic sacrocolpopexy, once ports are placed and the robot docked, introduction of robotic instruments should be done under camera visualization in a 3, 2, 1 consecutive order to increase efficiency; it can be difficult to rotate the camera to visualize placement of arms 2 and 3 if arm 1 has already been placed. Lastly, each arm's range of motion should be thoroughly assessed to minimize arm collisions during robotic pelvic surgery. Many of these technical issues have been overcome with the new da Vinci Xi® (Intuitive Surgical, Sunnyvale, CA, USA) robot, which has a much smaller and lighter weight camera and slimmer arms, allowing more range of motion and fewer problems with clashing.

Intraoperative Complications

During robotic sacrocolpopexy, it is our preference to begin with the dissection of the sacral promontory, in order to complete the more difficult portion of the surgery first. The 30° (down) camera is preferred by some surgeons, allowing for better visualization of the sacral promontory. This portion of the procedure requires adequate retraction of the sigmoid colon toward the left pelvic sidewall, in order to maintain optimal visualization of the sacral promontory. Prior to mobilization, however, the surgeon should thoroughly survey the abdomen and maneuver the small intestine into the upper abdomen if steep Trendelenburg positioning has not already accomplished this. Bowel injury during pelvic surgery, although occurring in only about 0.5% of cases, most commonly occurs in the small bowel at the time of intra-abdominal access (55%) and delay in identification of a bowel injury can result in mortality in an average of 3% of cases [27]. For this reason, it is imperative to be mindful of this complication and take extra time to evaluate for any potential injury during abdominal entry. If a puncture injury of the bowel is identified, a step-by-step inspection of the entire bowel is recommended to ensure no additional injuries are present. The most common cause of non-entry-related bowel injury is usually due to thermal defects, and these are more likely to go unnoticed.

Small serosal or muscularis defects should be repaired using 3-0 delayed absorbable sutures in a two layer, imbricating technique [28]. Recently, barbed suture has also been used for repair of bowel and bladder injuries with good results. This has been described with use of a single layer of 3-0 barbed suture for seromuscular injuries, while two layers of 3-0 barbed suture are used for full thickness defects. Additionally, some surgeons will use one layer of barbed suture for repair, followed by a second layer of continuous or interrupted delayed absorbable suture [29]. During small bowel repair, sutures should be placed perpendicular to the long axis of the intestine to prevent stricture formation. Conversely, large bowel enterotomies should be repaired with care to avoid any tension on the tissue. Given the larger lumen at this level, stricture formation is less likely; however, any suture tension at the level of the rectosigmoid colon could compromise the integrity of the repair. Although some injuries can be repaired laparoscopically, a number of bowel injuries may require laparotomy [27]. It is important to confer with colleagues intraoperatively at the time injuries are identified, as resection and temporary diversion may be required in some cases.

Avoidance of the above complications can be maximized with proper patient positioning in Trendelenburg, proper mobilization techniques and use of blunt tools for assistance. The small bowel should always be reflected first so that the large bowel can then secure hold of the small bowel out of the pelvis. Use of fan retractors may also prove helpful in laparoscopic procedures. In the obese patient, there may be redundant rectosigmoid colon, requiring cephalad mobilization and/or retraction. Scheib and coworkers has described use of an accessory stitch placed through the epiploic appendices and subsequent suspension of the colon to the anterior abdominal wall or left upper quadrant to remove the bowel from the operative field. Endoloops can also be used in a similar fashion and can be drawn out through ports and secured temporarily [14, 30].

Another significant complication of laparoscopic prolapse surgery, namely, sacrocolpopexy, is that of presacral hemorrhage. Although rare, this complication can be life threatening, and it is imperative to identify the middle and lateral sacral as well as common iliac vessels, the most common sites of hemorrhage in sacrocolpopexy. Although robotic sacrocolpopexy has been associated with lower overall blood loss when compared to both abdominal and laparoscopic approaches, a recent meta-analysis reported a 0.4% incidence of intraoperative vascular complications, namely, left iliac venotomy, with both laparoscopic and robotic approaches to sacrocolpopexy [31–33]. With this in mind, the surgeon should make it a priority to properly identify the sacral promontory as a landmark, which is best identified just below the bifurcation of the common iliac arteries. The assistant surgeon should be utilized to help with tactile feedback during this process. When incising the peritoneum overlying the promontory, one should be cognizant of the variability of the vascular pattern of the presacral space. There can be significant variability in the location of both sacral and iliac vessels, particularly on the left side of the anterior longitudinal ligament of the sacrum [34]. Many surgeons prefer to expose the ligament and vessels thoroughly in a layer-by-layer fashion, in order to minimize injury. The left common iliac vein has a highly variable course and can be difficult to identify as it often appears flat and white due to the effects of the pneumoperitoneum.

If presacral vascular injury is encountered, it has been well documented that conventional hemostatic measures oftentimes have proven to be futile, and this is likely due to the increase in hydrostatic pressure when in lithotomy position, as well as the fixed nature of the venous plexus to the sacral periosteum. When the hemorrhage is identified, it is important to communicate effectively with the patient side team and immediately apply direct pressure to the area with the nearest blunt robotic instrument. A RAY-TEK or cottonoid sponge can be passed into the field by the side surgeon, and this can also be used to apply direct pressure for a minimum of 5 min. If the bleeding persists, topical hemostatic agents should be considered. Germanos and coworkers described three cases of presacral hemorrhage which were successfully managed using a combination of a hemostatic matrix (Floseal®; Baxter, Hayward, CA, US), which should be directly applied over the area of bleeding, followed by application of an absorbable hemostat (Surgicel® Fibrillar; Ethicon, Somerville, NJ, US) that is applied over the top as a pad [35]. Topical hemostatic agent use should be accompanied by temporary pressure applied with gauze to secure the hemostatic matrix. Laparoscopic tacks or clips can also be placed and should be readily available in anticipation of vascular injury. Another method described in the literature utilizes absorbable hemostat material (Surgicel®), which is then secured in placed using laparoscopic fasteners. These fasteners are then anchored to the sacrum to apply targeted pressure to the bleeding area [36]. These techniques can only be utilized for relatively small sacral vessels. In the case of a common iliac venous injury, formal repair is critical to stop hemorrhage.

When these minimally invasive approaches fail, the surgeon should be prepared to convert to an open procedure. If a robotic approach is underway, the team should have an "emergency undock" protocol in place. The surgical and anesthesia teams should always be in constant communication regarding extent of blood loss and potential need for transfusion protocols to be activated. While preparing for conversion to laparotomy, pressure using a gauze, cottonoid, or blunt instrument must be maintained to prevent further hemorrhage. This can be accomplished with a robotic arm followed by a laparoscopic instrument through an accessory port when the robot is being undocked. Blood products should be ordered and brought to the operating room. Vascular instruments should be prepared and intraoperative vascular surgery consultation requested.

Urinary tract injury, although rare, is a conceivable complication of minimally invasive prolapse surgery, and many genitourinary injuries go unrecognized at time of the procedure. Minimally invasive sacrocolpopexy has been associated with intraoperative bladder injury rate of 0.4–3.3% and up to 10% in patients with post-hysterectomy vaginal vault prolapsed [32, 37]. While some of this could be due to the learning curve associated with newer robotic-assisted techniques, it is important to recognize the possibility of bladder injury and to be prepared to identify and attend to this complication, should it occur. Ureteral injury does appear to occur less frequently, and there is a paucity of literature to determine exact ureteral injury rate during laparoscopic prolapse repair specifically. That being said, laparoscopic hysterectomy has been most recently associated with a ureteral injury incidence of 0.02–0.54%, and incidence does not significantly differ between subtotal and total hysterectomy [38, 39].

In order to minimize risk of genitourinary injury, the surgeon should develop a command of the anatomy and knowledge of the most common sites of injury. Additionally, preoperative risk stratification and intraoperative assessment of ureteral and bladder integrity is essential in preparing for and preventing urinary tract complications. It is imperative to address patient-specific risk factors, such as prior pelvic surgical history and anomalous anatomy. History of three or more previous cesarean sections comes with a cystotomy rate of 20% in the setting of laparoscopic hysterectomy [40]. With regard to type of injury, the dome of the bladder is most commonly involved in injury during total hysterectomy while the most common sites of ureteral injury occur in close proximity to the uterine artery or at the pelvic brim, near the infundibulopelvic ligament. Identification of the vesicovaginal junction is crucial to avoiding bladder injury. The placement of a sponge stick or end-to-end anastomosis (EEA) sizer vaginally can help with mobilization of the vagina and detection of the plane between the vagina and bladder. This dissection should be bloodless and areolar tissue should be easily identified. If bleeding is encountered, the surgeon should suspect compromise of bladder wall integrity. Bladder insufflation can also prove helpful during this time to ensure proper dissection. If bladder injury occurs, a double layer closure should be performed with 2-0 or 3-0 absorbable sutures after dissection is complete. Bladder repair can also be successfully performed with barbed suture or a combination of the two types [29]. Subsequently, a retrograde fill of the bladder should be performed to ensure adequate closure. We recommend indwelling catheter placement for 5–14 days, depending on size and location of the defect.

Transperitoneal identification of the ureter can usually be performed at the level of the pelvic brim, and the ureter can be coursed from this point. This technique should be routinely performed whenever possible to decrease risk of ureteral injury; however, in patients with aberrant anatomy or those who have had multiple abdominal surgeries, this may be difficult. In these instances, use of prophylactic ureteral catheterization may reduce the risk of injury during high-risk procedures although routine use is debated, and this practice should not take the place of meticulous surgical technique [41]. Additionally, the use of ureteral stents can be limited when a robotic technique is employed, due to lack of tactile feedback. Recently, Siddighi and coworkers [42] described the use of indocyanine green (ICG) to identify ureters intraoperatively. Prior to the start of surgery, 25 mg of ICG was dissolved in 10 mL of sterile water and injected into each ureter through a 6-French ureteral catheter. The ICG injection resulted in reversible staining of ureters through protein binding for the entirety of each of ten gynecologic surgeries. There were no adverse events described at the time of the operation or up to 2 months postoperatively and cost was approximated at $100 per 25 mg of ICG. This technique can be utilized in anticipation of abnormal anatomy or high-risk prolapse cases when performing robotic-assisted prolapse repair; this technique should be considered as part of one's armamentarium when treating patients with risk factors for urinary tract injury, such as those with diagnoses of endometriosis, multiple abdominal surgeries, ectopic ureter insertion, or duplication of urinary collecting system. If ureteral injury is identified intraoperatively, the ureter should be adequately mobilized and the injured segment is excised prior to ureteroureterostomy using 4-0 absorbable sutures. Intracorporeal placement of a JJ stent can then be performed. Good success rates of this repair have been described using robotic techniques [43]; however, ureteral repair may require laparotomy at times, as well as consultation with other subspecialty services.

Lastly, vaginotomy has been quoted as a fairly common complication of minimally invasive POP repair and has been associated with an incidence from 0.4% up to that of 24% in robotic assisted sacrocolpopexy with patients who had post-hysterectomy vaginal vault prolapsed [32, 33]. The presence of this complication has been associated with postoperative vaginal mesh exposure, and for this reason it is of utmost importance to take precautions when performing vaginal dissection [44]. To minimize vaginotomy risk, an EEA sizer or vaginal stent can be placed in the vagina and elevated cephalad either anteriorly or posteriorly by the assistant. This allows the surgeon at the console to delineate vesicovaginal and rectovaginal planes appropriately when performing the vaginal dissection. In cases of post-hysterectomy vaginal vault prolapse, it is important to also be mindful of the cuff closure site, as this is usually the area of thinnest peritoneum. Dissection in this area should be only performed after a clear plane has been identified, as vaginotomy is more likely to occur here [45]. It is our preference to leave the peritoneum intact whenever possible and we routinely forego dissection of the posterior peritoneum off of the cervical stump when performing supra-cervical hysterectomy robotically. We prefer to maintain the peritoneal integrity here to reduce risk of mesh extrusion as it is felt additional dissection in this area is not significantly helpful. In cases where vaginotomy does occur, it is imperative to reinforce this area with a second imbricating layer of suture. Additionally, mesh should not be placed directly over any vaginotomy site. We routinely continue to perform supracervical hysterectomy with sacrocolpopexy rather than total hysterectomy to further minimize mesh exposure or extrusion risk. This is done unless the patient has known cervical pathology or some other medical indication requiring removal of the cervix. We prefer Gor-Tex® (Gore Medical, Flagstaff, AZ, USA) sutures for anterior and posterior mesh fixation, as their monofilament structure makes vaginal extrusion less likely.

Postoperative Complications

Although overall morbidity remains lower and recovery time is usually shorter in the setting of comparable success rates with an open approach, postoperative complications do occur with minimally invasive sacrocolpopexy [6, 8, 9, 32, 37, 46]. It is important to recognize those that occur most often, so that one may anticipate these setbacks and tend to them in a timely fashion.

Postoperative surgical site infection (SSI) is found to occur at a rate of approximately 2–4% during minimally invasive hysterectomy and sacrocolpopexy procedures, and this complication is associated independently with intra-/postoperative blood transfusion and longer operative time [37, 47]. These characteristics are likely representative of longer, more complicated surgeries. Possible reasons for wound infections could include failure to redose antibiotics during longer cases, prolonged tissue and or trocar manipulation, increased risk of violation of sterile technique and larger potential for thermal or glycemic disregulation. The surgeon should always be mindful of the time and discuss potential need for redosing of antibiotics with the anesthesia team. Antimicrobial prophylaxis guidelines should be reviewed. Most often, cephalosporins are used for minimally invasive POP repair. In general, redosing should occur after 4 h or with >1500 mL blood loss. Additionally, patients over 120 kg should receive 3 g initially instead of the standard 2 g dosing. OR assistants should also assist with periodic evaluation of trocar sites or need for repositioning to decrease tissue damage during the case that could lead to SSI postoperatively [48]. If wound infection does occur, antibiotics to cover Gram-positive organisms should be initiated, as these organisms are most commonly associated with SSI in those individuals undergoing gynecologic/urogynecologic procedures [49, 50]. Any area of erythema around the surgical site should be clearly demarcated. Although the routine use of preoperative antiseptic scrubs has been debated, there is evidence to show that this technique reduces rate of antibiotic resistant SSI, and use may be considered in patients with predisposing risk factors to wound infection [50–52].

Another postoperative complication to be aware of is that of venous thromboembolism, which is thought to come with a risk of approximately 14% in gynecologic surgery for benign disease [53]. Although there is no consensus on VTE prophylaxis for patients undergoing pelvic reconstructive surgeries, it should be noted that many of these patients are defined as "high risk" solely on the basis of age >60 years which comes with a general VTE risk of 20–40% [54]. Both the AUA and ACOG recommend the use of anticoagulation in "high-risk" populations undergoing high-risk surgeries such as vaginal wall repairs and sacrocolpopexy [55, 56]. Given the average age of the patient undergoing POP repair, strong consideration should be given to these recommendations and benefit of heparin intraoperatively should be weighed against individual bleeding risk. That being said, the use of pneumatic compression devices should be employed routinely, independent of other anticoagulation, unless the patient has a contraindication to this. If a VTE is suspected, the patient's pretest probability should be calculated and diagnostic tests should be performed. Davis [57] provides a concise review of clinical models used for diagnosis and treatment of VTE in gynecologic surgery. These algorithms can be helpful when choosing treatment method and duration for patients.

Bowel complications after minimally invasive sacrocolpopexy can range from very painful constipation to bowel obstruction secondary to adherence of intestines to exposed abdominal mesh. While bowel obstruction rates are rare, ranging from 0.4 to 1.7% [37], overall rates of bowel dysfunction far surpass this, with an incidence rate of 5–14% in a recent meta-analysis of robotic-assisted sacrocolpopexy. The most common types of dysfunction cited were dyschezia, obstructed defecation and outlet constipation [31]. Recent studies suggest that having concomitant posterior prolapse repair does not increase bowel dysfunction rates, and these symptoms may be related to surgical technique of sacrocolpopexy [58]. It is imperative to place the mesh as flat as possible against the sacral promontory and to avoid attachment to the levator ani musculature in order to decrease anorectal dysfunction postoperatively. Extensive dissection in the rectovaginal septum should be avoided to reduce the risk of rectal denervation injury. Additionally, management of expectations is important in this area. Patients should understand that average time to first bowel movement (BM) is estimated at 3 days after prolapse surgery, and a recent RCT revealed no difference in average time to BM with a more rigorous bowel regimen. Additionally, bowel movements were comparatively painful in both groups and those with higher incidence of postoperative narcotic intake had higher postoperative pain scores associated with bowel movements [59]. These data are compelling and clearly more research in this area is indicated. Since there is no consensus in the literature for bowel dysfunction reduction, we use various techniques to attempt to mitigate this postoperative issue. In order to reduce narcotic use, which is a known contributor to constipation, we implement the use of Toradol 30 mg every 6 h as a standing regimen with narcotics only for breakthrough pain. When transitioning to PO regimen, patients are encouraged to use 800 mg Ibuprofen or 1 g of Tylenol every 8 h. Additionally, patients are started on twice daily stool softeners and a powder laxative 1–2 times daily postoperatively and encouraged to continue this regimen until BMs are regulated.

Nausea and emesis should always provoke the question of ileus or small bowel obstruction postoperatively. Many times, this can be managed conservatively with clear liquid diet or nasogastric tube. At times, obstruction persists, requiring reoperation, and the decision about this intervention should be made on a case-by-case basis. Surgical technique may again contribute to an obstruction of the bowel, and debate exists about whether obstruction is, in most instances, directly related to mesh placement or exposure. In a recent review, surgeons found similar obstruction rates with and without re-peritonealization of sacrocolpopexy mesh [60]. Conversely, one case series demonstrated two cases of delayed obstruction to be directly attributable to the barbed suture used to re-peritonealize the sacrocolpopexy mesh [61]. These are important cases to consider. At our institution, we do utilize barbed suture to routinely re-peritonealize sacrocolpopexy mesh; however, we make sure to cinch tissue after each throw of suture to reduce barbed suture exposure, and we routinely cut suture ends flush with peritoneal tissue to decrease the risk of this complication.

Various other mesh complications can also arise, including pelvic pain or dyspareunia, mesh infection, and mesh extrusion. Patients should be extensively counseled on the possibility of these mesh-related complications and the low but present risk of need for reoperation due to mesh complications, which was found to occur at a rate of 2.9% in a recent review article [62]. Mesh extrusion rates associated with minimally invasive sacrocolpopexy hover around 2–3% [33, 37] and are shown to be higher with silicone-coated polyester and polytetraflouroethylene mesh materials [62]. For this reason, use of these mesh types is not recommended. We routinely perform supracervical hysterectomy with minimally invasive sacrocolpopexy to avoid higher rates of mesh extrusion [62], unless there is a medical indication to remove the cervix at the time of prolapse repair. Although pain and dyspareunia are found to be less with sacrocolpopexy when compared to vaginal prolapse repairs, these issues still do occur. If pain occurs in the absence of mesh extrusion and conservative measures such as analgesics, local hormone therapies or local anti-inflammatory injections fail, reoperation to remove the mesh may be necessary. When evaluating these patients, differential diagnosis should include bowel or bladder mesh erosion, suture erosion, lumbosacral discitis, and osteomyelitis. Possible diagnostic tests should include and not be limited to cystoscopy, colonoscopy, CT scan, and MRI. There are case reports to support the utility of these tools when evaluating post-sacrocolpopexy pain [63].

While extremely rare, back and/or buttock pain accompanied by acute signs of infection could denote pyogenic spondylitis. This class of lumbosacral infections requires immediate attention and can be life threatening. It is imperative to avoid the L5-S1 disc and to localize the sacral promontory and avoid the sacral nerve, which is most commonly found approximately 3 cm from the upper surface of the sacrum and 1.5 cm from the midline [64]. Sutures should be placed at or below the sacral promontory to avoid the disc space and when this is not possible, surgeons should be mindful of the 1–2 mm thickness of the anterior longitudinal ligament and place sutures no deeper than this to avoid the disc itself [65]. This complication may often require reoperation and removal of mesh and suture, followed by a prolonged course of broad-spectrum antibiotics.

Lastly, de novo stress urinary incontinence can occur following sacrocolpopexy in the minimally invasive setting and the need for further intervention with mid-urethral sling placement in these patients can far exceed 10% [31]. We routinely perform clinical evaluation to assess for occult SUI if the patient does not identify with this symptom profile. Furthermore, we have implemented a “shared decision-making” model into our practice, when considering concomitant anti-incontinence procedures in this setting. It is crucial to assess anterior and apical support vaginally at the time of sacrocolpopexy mesh fixation, to ensure that overcorrection of the anterior compartment has not occurred. If there appears to be tension on the tissues of the anterior vaginal wall or splaying of the urethral meatus, adjustment may need to be considered.

Overall, sacrocolpopexy, whether done via laparoscopic or robotic route, is an extremely safe and effective form of pelvic organ prolapse repair. These modes of surgery are rapidly becoming the new gold standard, as minimally invasive techniques are found to be more appealing to both patient and surgeon; minimally invasive sacrocolpopexy has comparable profiles of safety and feasibility, parameters that will only continue to improve with enhancement of surgeon efficiency. It is crucial, however, to acknowledge the unique set of complications that may accompany minimally invasive approaches to sacrocolpopexy, so that we may be equipped to avoid surgical pitfalls and optimally prepared to treat complex situations, should they occur. Surgeon understanding of the complications associated with minimally invasive sacrocolpopexy provides for consensus to develop best practices, which can help to decrease the incidence of these complications and increase overall patient satisfaction associated with these procedures.

Summary

Table 10.1 offers an excellent summary for avoiding complications of minimally invasive female Pelvic organ prolapse repair.

Table 10.1 Avoiding complications of minimally invasive female pelvic organ prolapse repair

Preoperative considerations	
Patient history and physical exam	• Thorough assessment of tolerance of abdominal insufflation/Trendelenberg positioning
	– Smoking history, exercise tolerance, obesity
	– Cardiopulmonary/renal disease
	– Increased ICP
	– Hypovolemic state
	• Abdominal survey for scars, hernias, and understanding of prior pelvic surgeries, anatomical variants
	• Uterine mobility, adnexal mass
	– Lateral mobility ≥2 cm for uterine vessel access
	• Gentle preoperative bowel prep only when deemed necessary (surgeon preference)
	– Mg Citrate, Miralax
Patient positioning and surgical setup	• Proper use of corporeal padding
	• Joint flexion at maximum angle of 30°
	• Anti-skid materials to decrease risk of nerve injury
	– Pink pad, egg crate, surgical beanbag
	• Facial padding, eye taping to reduce facial injury
	– Direct facial trauma responsible for 20% of corneal abrasions
	• Be mindful of degree of Trendelenberg positioning absolutely necessary
	– Less steep degree may decrease morbidity without negative effects on surgical time, visibility (Ghomi et al.)
	• 30° camera for optimal sacral visualization
	– If distance from umbilicus to pubic symphysis <15 cm, camera port should be supra-umbilical
	• Direct visualization and abdominal survey during trocar insertion
	– Port site bleeding most commonly from perforation of inferior epigastric artery
	– 55% of bowel perforations occur during intra-abdominal access
	• Use of 8-mm or 5-mm accessory port to decrease hernia risk

(continued)

Table 10.1 (continued)

Intraoperative complications	
	• Port site bleeding
	– Attempt to cauterize injured vessel with offending trocar in place
	– Tamponade can be attempted using a 12-Fr foley catheter through trocar
	– Sutures can be placed at each side of trocar site and tied externally with removal after 24–48 h
	• Bowel injury
	– Use of fan retractors, accessory stitch, Endoloop to retract bowel effectively
	– If injury detected vicryl or barbed suture can be used for repair
	– Repair should be performed in two layers with sutures placed on the long axis of intestine to prevent stricture
	• Presacral hemorrhage
	– Middle and lateral sacral vessels should be well delineated
	– Assess for variability of sacral/iliac vessels, particularly on the left side of anterior longitudinal ligament
	– Apply direct pressure with a RAYTEK or cottonoid as first line treatment
	– Hemostatic agents (Floseal, Surgicel) and laparoscopic vessel fasteners should be readily available
	• Urinary tract injury/vaginotomy
	– Use of EEA sizers or vaginal stents to allow for proper visualization of vesicovaginal junction
	– Dissection of this junction should be bloodless if correct plane has been identified
	– 25 mg ICG in 10 mL sterile h20 can be injected into ureters prior to RASC for ureteral identification
	– Bladder/vaginal injury should be repaired in a double, imbricating layer using vicryl or barbed suture
	– Mesh should not be placed directly over vaginotomy site, should one occur
Postoperative issues	
	• Surgical site infection
	– Cephalosporins should be redosed intraoperatively after 4 h or with >1500 mL blood loss
	– Patients >120 kg should receive a 3 g initial dose instead of standard 2 g dosing
	– Postoperative antibiotics for wound infection should be targeted at Gram-positive bacteria
	• VTE
	– LMWH should be considered in patients >60 yo, as they are deemed “high risk” with VTE risk 20–40%
	• Bowel complications
	– Dyschezia, obstructed defecation, and outlet constipation are the most common types of post-op bowel dysfunction and patients should not expect a bowel movement within the first 3 days after surgery
	– Extensive dissection of rectovaginal septum should be avoided to reduce bowel denervation
	• Mesh complications
	– Mesh should be placed as flat as possible and against sacral promontory to decrease anorectal dysfunction
	– Supracervical hysterectomy is preferred to reduce mesh extrusion rates
	– Use of lightweight type I mesh to reduce risk of graft infection
	• De novo SUI
	– Vaginal examination should be performed intraoperatively to assess for anterior/apical overcorrection which could lead to new onset stress urinary incontinence

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