Robotic groin hernia repair

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INTRODUCTION

Groin hernias are a common problem: 27 percent of all men and 3 percent of all women will experience a clinically apparent groin hernia in their lifetime [1]. While nonoperative management is acceptable in the short term for oligosymptomatic groin hernias, the majority will require surgery due to progression of symptoms or concern for incarceration or strangulation [2,3].

Worldwide, 20 million patients undergo groin hernia repair every year [4]. A number of surgical options exist, including open suture (tissue) repair, open mesh repair, and laparoscopic mesh repair. Robotic, also referred to as robotic assisted laparoscopic (RAL), repair has evolved as another surgical approach. The first reported robotic inguinal hernia repairs were described in 2007 by urologists who repaired inguinal hernias at the time of robotic prostatectomy [5]. Since that time, robotic groin hernia repair has grown steadily; as an example, the use of robotic surgery for inguinal hernia repair increased from 0.7 to 28.8 percent from 2012 through 2018 according to data from the Michigan Surgical Quality Collaborative [6]. In a retrospective review of United States Medicare claims, the use of robotics for groin hernia repair increased from 2 percent in 2010 to 3.9 percent in 2017. Patients undergoing robotic surgery were older and had more comorbidities than those undergoing laparoscopic surgery, suggesting that robotics is being used in more challenging clinical situations [7].

The indications, contraindications, techniques, and outcomes of robotic groin hernia repair are discussed here. The clinical features and diagnosis of a groin hernia, the technical details of performing an open or laparoscopic groin hernia repair and how to choose between the two techniques, the complications of groin hernia repair, and the treatment of recurrent groin hernias in adults are discussed in other topics:

- (See "Classification, clinical features, and diagnosis of inguinal and femoral hernias in adults".)
- (See "Overview of treatment for inguinal and femoral hernia in adults".)
- (See "Open surgical repair of inguinal and femoral hernia in adults".)
- (See "Laparoscopic inguinal and femoral hernia repair in adults".)
- (See "Complications of inguinal and femoral hernia repair".)
- (See "Recurrent inguinal and femoral hernia".)

INDICATIONS

Primary hernia — In general, groin hernias should be repaired when they are clinically apparent (ie, noted on clinical examination) **and** causing patient symptoms, including discomfort, pain, or affecting activities of daily living. For asymptomatic and oligosymptomatic hernias, surgical repair, as opposed to expectant management (eg, watchful waiting or initial nonoperative management), should be based upon shared decision-making between the patient and their health care provider. The indications for surgical repair of groin hernias are discussed elsewhere. (See "Overview of treatment for inguinal and femoral hernia in adults", section on 'Inguinal hernia'.)

Rates of recurrence are similar between the open and laparoscopic approaches [8,9]. Surgeons should choose the approach with which they are most comfortable and most experienced. For surgeons who are equally facile with both open and minimally invasive repairs, a minimally invasive approach should be considered, particularly for patients with obesity, patients at increased risk for surgical site infection (eg, diabetic patients, immunocompromised patients, smokers), patients with recurrence from a prior open repair, bilateral hernias, or femoral/obturator hernias [8,10]. In women with groin hernias, a minimally invasive approach may be preferred because of the higher rates of femoral hernias, which may be missed during an open repair. Given the added costs associated with minimally invasive repair, consideration should be given to open mesh repair for low-risk patients undergoing the initial repair of a unilateral groin hernia. While the risk is small, minimally invasive groin hernia repair carries a risk of vascular and visceral injury that is less common when using an open approach [8,11]. (See "Overview of treatment for inguinal and femoral hernia in adults", section on 'Inguinal hernia'.)

Given the data currently available of all minimally invasive groin hernia repairs being equal, the choice between laparoscopic and robotic repair should be made based upon surgeon expertise, availability of equipment, and surgeon/patient preference (again, shared decision-making).

Occult contralateral hernia — Occult groin hernias are hernias only seen on radiographic imaging or noted at the time of operation but not apparent on clinical examination. An occult contralateral hernia may be identified at the time of robotic or laparoscopic unilateral groin hernia. Approximately 16 percent of patients undergoing robotic inguinal hernia repair were found to have an incidental contralateral inguinal hernia [12].

At this time, some surgeons routinely repair a contralateral occult hernia if identified, and others repair only symptomatic hernias. Studies on this topic remain inconclusive [13,14]. We believe that either approach is acceptable, so long as the patient is involved in the decision-making process up front. (See 'Preoperative preparation' below.)

There is limited evidence as to whether occult groin hernias should be repaired at the time of initial operation. The advantages of repairing an incidentally diagnosed occult contralateral groin hernia are to prevent hernia-related symptoms in the future and reduce resource utilization through fewer hospital visits, operations, and less time away from work. The disadvantages of this approach include the potential complications associated with groin hernia surgery, such as chronic groin pain. It is unclear how often contralateral occult hernias become symptomatic, but it is known that up to 25 percent of hernias repaired using a minimally invasive technique develop chronic pain [15].

CONTRAINDICATIONS

The only absolute contraindication for robotic groin hernia surgery is patient intolerance to general anesthesia and/or pneumoperitoneum. While an open groin hernia repair can be performed under local anesthesia with sedation, robotic repair requires general anesthesia in order to establish pneumoperitoneum. Patients with certain cardiopulmonary conditions may not tolerate pneumoperitoneum.

Relative contraindications for robotic groin hernia surgery are related to anatomical factors of the hernia or comorbid conditions of the patient and include (see "Overview of treatment for inguinal and femoral hernia in adults", section on 'Noncandidates for laparoscopic repair'):

- **Prior pelvic surgery –** With the robotic approach, the abdominal wall and hernia defect are approached posteriorly (dorsum) with placement of mesh in the preperitoneal/transversalis fascial space. Such tissue planes are more likely to have been obliterated or made inaccessible by prior pelvic surgery. A history of pelvic radiation is similarly a relative contraindication for robotic groin hernia repair for the same reason.

  Thus, the level of surgeon experience should be considered before undertaking robotic groin hernia repair in patients who have a history of pelvic surgery, including prostatectomy, bladder surgery, kidney transplantation, and a prior laparoscopic or robotic groin hernia repair. For less experienced surgeons, it may be more prudent to perform the surgery from an open anterior (ventral) approach in patients with prior pelvic surgery or radiation, where the tissue planes are less likely to be scarred or damaged.

  However, for experienced surgeons, robotic groin hernia surgery after prior pelvic surgery is safe. As examples, a systematic review and meta-analysis of patients with prior prostatectomy suggests that minimally invasive inguinal hernia repair can achieve complication rates similar to an open approach, similar rates of recurrence and chronic groin pain, and low rates of conversion [16]. However, none of the included studies were randomized controlled studies, and most had a moderate or serious risk of bias. Another meta-analysis on minimally invasive hernia repair after prostatectomy identified low risks of recurrence (1.1 percent at mean 18 months), chronic pain (1.9 percent), and conversion to open procedure (0.8 percent) in this population [17].

- **Cirrhosis with collateral circulation and/or ascites –** While cirrhosis in itself is not necessarily a contraindication to minimally invasive approach, violation of the peritoneum should be avoided in patients with ascites. In addition, among patients with periumbilical collateral circulation (eg, caput medusa), there may be an increased risk for bleeding with port placement.

- **Large scrotal hernias defined as >3 cm –** Hernias that significantly extend into the scrotum can be challenging to repair. This contraindication is applicable to both totally extraperitoneal (TEP) and transabdominal preperitoneal (TAPP) repair, although some surgeons believe TAPP repair is more amenable to minimally invasive repair of large scrotal hernias due to the increased working space and improved maneuverability. Risks include conversion to open, injury to cord structures, and an incomplete hernia sac dissection.

- **Strangulated or incarcerated hernias –** Open repair of strangulated or acutely incarcerated groin hernias is appropriate. However, if no contamination is suspected, and the hospital can accommodate robotic surgery on an emergency basis, a robotic approach may be attempted as long as the patient is aware that conversion to open may be required depending on the intraoperative findings. In cases where contamination is likely, minimally invasive repair with synthetic mesh has not yet been proven to be safe, and an open approach should be selected.

PREOPERATIVE PREPARATION

- Obtain informed consent that stipulates whether or not to repair a contralateral occult groin hernia if identified. (See 'Occult contralateral hernia' above.)

- Prophylactic antibiotics should be administered prior to skin incision (table 1). (See "Antimicrobial prophylaxis for prevention of surgical site infection in adults".)

- How to decompress the bladder is at the surgeon's discretion. While the patient can simply be asked to void right before the start of straightforward cases, consideration should be given to placement of a Foley catheter when a higher level of complexity is anticipated (such as scrotal hernias or cases where part of the bladder is within the hernia sac). Of note, the incidence of postoperative urinary retention (POUR) is as high as 18 percent in patients undergoing robotic inguinal hernia repair (laparoscopic 14.8 percent and open 6.3 percent) [18]. Patients should be advised of this risk as part of the shared decision-making process. We routinely screen male patients preoperatively for symptoms of benign prostatic hyperplasia using the International Prostate Symptom Score. If patients score high, we will recommend a prophylactic alpha blocker and/or refer them to a urologist for further evaluation [19,20]. Whether intraoperative Foley catheter placement prevents or exacerbates the development of POUR has yet to be determined [21]. (See "Laparoscopic inguinal and femoral hernia repair in adults", section on 'Preoperative evaluation and preparation'.)

- In order to reduce operating room costs for robotic cases, attention should be paid to eliminating all unnecessary disposable equipment. For example, disposable trocars, the suction-irrigator, and the vessel sealer should be available but only opened on a case-by-case basis. Likewise, robotic groin hernia repair can easily be performed with three robotic instruments (scissors connected to monopolar cautery, needle driver, and grasper) and, in some experienced hands, only two (scissored needle driver and grasper), thereby limiting the charges associated with the use of each robotic instrument. (See 'Cost' below.)

SURGICAL TECHNIQUES

In minimally invasive groin hernia surgery approached either laparoscopically or robotically, placement of mesh is an essential step. While repair of the defect using sutures only may be feasible in certain cases, this technique is not widely adopted or accepted. Two different laparoscopic approaches are available for repair of groin hernias, including the totally extraperitoneal (TEP) repair and the transabdominal preperitoneal (TAPP) repair. The TAPP hernia repair is the technique most commonly utilized in conjunction with the robot; robotic TEP repairs are currently being explored as a possible alternative approach to groin hernia repair. (See 'Total extraperitoneal (TEP) robotic groin hernia repair' below.)

Our standard technique — Our technique of robotic TAPP groin hernia repair is presented in detail below (movie 1). Variants to the standard technique and other controversial issues are discussed in the following section. (See 'Variant techniques and special considerations' below.)

- Patient positioning – Patients should be positioned supine with both arms thoroughly padded and tucked at the sides. Following port placement, Trendelenburg positioning will provide enhanced access to the inguinal spaces. Depending on room setup, angling of the bed may facilitate docking of the robot.

- Initial abdominal entry may be accomplished either by Veress needle, direct Hasson open cutdown, or optical trocar. Selection of entry technique is dependent upon surgeon preference. Our preference is entry in the upper quadrant with an optical trocar. Insufflation of the abdominal cavity and visualization of the peritoneal space upon introduction of a laparoscope confirm adequate initial port placement. Pneumoperitoneum should be maintained at 15 mmHg but can be decreased later in the case to facilitate closure of the hernia defect or peritoneal flap.

- Port placement – Traditional port placement includes one periumbilical port and one port on either side, spaced at least 5 to 10 cm apart and 15 to 20 cm from the operative field (table 2). Our preference is to place all ports off midline to minimize risk for port site hernias.

- Docking of the robot – Positioning of the robotic system depends on room setup and the type of platform being utilized. Side docking in parallel or perpendicular is generally used (picture 1). However, the robot can also be docked in between the legs with the patient in lithotomy position if the room is more amenable to this setup. Docking from either the right or left side of the patient allows for bilateral access and should be chosen based on room setup rather than laterality of the hernia.

- Identification of hernia defect – Inspect bilateral inguinal and femoral orifices for defects. One advantage of robotic groin hernia repair is the ability to visually confirm the presence of a hernia before initiating repair.

- Opening of peritoneum/transversalis fascia – The peritoneum/transversalis fascia is opened using scissors or electrocautery from the anterior superior iliac spine to the median umbilical ligament below the arcuate line or about 7 cm cephalad to the pubis (movie 1). Care should be taken to identify the inferior epigastric vessels and avoid injury.

- Identification of Cooper's ligament – Medial dissection within this space will expose Cooper's ligament. This dissection should continue inferiorly between Cooper's ligament and the bladder to create enough space for mesh placement. In addition, the space between Cooper's ligament and the iliac vein should also be exposed in order to rule out a femoral hernia (figure 1). For large direct defects, extend the dissection to the contralateral Cooper's ligament in order to create enough space for adequate mesh coverage. Care should be taken to avoid the corona mortis if identified. This is a venous or arterial connection between the obturator and external iliac or inferior epigastric vessels. It is typically located behind the superior pubic ramus in the retropubic space and is present in about 50 percent of people [1,22].

- Dissection of the hernia sac off of the cord structures – For indirect hernias, careful dissection of the hernia sac, typically anterior medial, off of the cord structures is undertaken. Compete dissection of the peritoneum is essential to avoid recurrence and folding of the inferior edge of the mesh. Care should be taken to identify and preserve the vas deferens (figure 1). Cord lipomas, typically lateral, should be completely reduced, even if they initially appear small. In women, division of the round ligament is acceptable and may facilitate mesh placement. However, if this is undertaken, the round ligament should be divided at the level of the peritoneum to avoid injury to the genital branch of the genitofemoral nerve. In addition, care should be taken to ensure hemostasis as the artery of Sampson runs just underneath the round ligament. It should also be noted that concerns have been raised about uterine prolapse as a long-term complication of bilateral round ligament division during inguinal or femoral herniorrhaphy. However, this concern is theoretical and has not been studied. Both authors prefer to preserve the round ligament but will divide it if this optimizes the dissection or facilitates mesh placement.

- For large direct inguinal hernia defects (>3 cm in size), our preference is to close the defect with running a 2-0 barbed suture, which can also be used to secure the mesh [23-25]. In order to facilitate closure of the hernia defect, surgeons have the option of reducing the insufflation pressure to 8 to 10 mmHg. (See 'Primary closure of direct defect' below.)

- Confirm a critical view of the myopectineal orifice (picture 2). The components of this critical view include [26]:

  - Cooper's ligament, 2 cm inferior to the ligament, and the area between Cooper's and the iliac vein.

  - Peritoneum cleared off of the cord structures to the psoas muscle; ensure that there is no tugging of the cord when the peritoneal flap is lifted and no remaining tail of an indirect sac.

  - Reduction of cord lipomas if applicable.

- Lateral dissection of the peritoneum to the anterior superior iliac spine (ASIS) with space sufficient to accommodate a piece of mesh at least 10 x 15 cm.
- Document clearance of the myopectineal orifice in the operative note.

- Placement of mesh – Mesh should adequately cover all hernia defects with medial overlap of the pubic tubercle and Cooper's ligament, lateral coverage to the ASIS, and a posterior (dorsal) edge that is in line with the widely dissected peritoneal reflection. A piece of mesh at least 10 x 15 cm in size is required. However, use of a larger piece (16 x 20 cm) should be considered in patients with large direct defects, multiple defects, or a wide pelvis. One author of this topic prefers self-fixating mesh because placement is faster and does not require suture fixation. The second author prefers mid-density polypropylene mesh due to equivalent clinical results and lower cost. Fixation of the mesh is dependent on the type of mesh selected. Creation of a key hole to accommodate the cord structures is generally not indicated. Avoid wrinkling of the mesh. Alternative mesh selections and fixation methods are also discussed. (See 'Mesh selection' below and 'Mesh fixation' below.)

- Test the repair under direct visualization by temporarily reducing the pressure of the pneumoperitoneum to ensure there is no folding of the mesh at the medial and inferior edges.

- Closure of peritoneum – Closure of the peritoneal flap is achieved with the use of a running absorbable suture. If a barbed suture is selected, care should be taken to avoid leaving exposed barbs as several case reports have described injury to the bowel. Any holes that were created in the peritoneal flap during the dissection should be similarly closed. Any remaining holes in this flap are a site of potential intestinal herniation and/or incarceration.

- Removal of all needles and closure of port sites greater than 8 mm. All port sites greater than 8 mm are closed with a suture-passer. Closure of the 8 mm ports is at the surgeon's discretion. One author does not routinely close these sites, while the other author routinely closes these sites with a suture passer.

- Surgeons should consider performing a field block under direct laparoscopic visualization or ultrasound guidance using a long-acting local anesthetic such as bupivacaine. It is our practice to infiltrate the port sites and perform a field block (ilioinguinal or transversus abdominis plane block) with bupivacaine at the end of the case.

Variant techniques and special considerations

Mesh selection — The most common mesh types used for groin hernia repairs are composed either of polypropylene or polyester. Self-fixating mesh and/or three-dimensional mesh that has laterality for the affected side are commercially available and should be chosen based on surgeon preference and consideration of product cost [4]. Because no clinical trials on mesh type for robotic groin hernia repairs have been published to date, mesh selection is guided by data from laparoscopic repairs [27-29].

In redo cases, if the peritoneal flap is not expected to be completely closed following the repair due to thinning or tear, consideration should be given to use of a coated mesh sewn circumferentially within the remaining defect. Exposed, uncoated meshes may adhere to or erode into intestine. (See 'Recurrent hernias' below.)

Mesh fixation — Fixation of the mesh is dependent on type of mesh selected and surgeon preference. Self-fixating mesh requires no sutures or tacks. Other meshes can be secured with sutures, tacks, or surgical glue, or not fixated.

With sutures or tacks, it is generally accepted to secure the mesh at three points: (1) Cooper's ligament just medial to the corona mortis, avoiding the periosteum, (2) just above the pubis at the insertion of the rectus muscle, and (3) the rectus muscle either medial or lateral to the epigastric vessels depending on the position of the hernia defect.

Care should be taken to avoid placement of sutures or tacks particularly below the iliopubic tract, due to the risk of nerve entrapment (ie, triangle of pain (figure 1)).

A systematic review on fixation of mesh for laparoscopic inguinal hernia repair demonstrated no differences in recurrence or surgical site infection [30-34] regardless of technique. Trials that looked at different mesh fixation techniques and the development of chronic pain or quality of life have been equivocal, and, therefore, no conclusions or recommendations have been made. However, the HerniaSurge group cautions against nonfixation for larger medial defects (direct hernia defects >3 cm), citing the high recurrence risk and lack of data on this specific subgroup of inguinal hernias [4]. We agree with this and routinely fix the mesh when the hernia defect is direct and larger than 3 cm.

Primary closure of direct defect — Anecdotally, among surgeons who perform robotic inguinal hernia repairs, some will close large medial defects (direct hernia defects) prior to mesh placement. To date, only one randomized clinical trial has been published. This included 60 patients with only seven days of follow-up and demonstrated decreased seroma formation in patients who underwent defect closure. One meta-analysis on this topic that included this randomized trial, as well as two prospective and three retrospective studies, found decreased recurrence rates with defect closure (odds ratio 0.21, CI 0.07-0.63) but no difference in the incidence of seroma or chronic pain [23-25].

For large direct hernia defects with thinning of the floor of the inguinal canal, consider imbricating the tissue using small suture bites. If undertaken, attention should be paid to the course of nerves anterior to the internal ring to avoid entrapment with sutures (figure 1).

Recurrent hernias — Thinning of the peritoneum may be encountered during recurrent groin hernia repair. In these cases, care should be taken to proceed with the peritoneal flap dissection carefully. Minimizing handling of this layer can help to maintain its integrity. Following the repair, if the peritoneal flap cannot be completely closed, consideration should be given to use of a coated mesh sewn circumferentially within the remaining defect. (See 'Mesh selection' above.)

Any previously placed mesh, tacks, suture material, or mesh plugs encountered during robotic repair should be excised in order to facilitate adequate hernia repair. Removal of these materials may also help in patients experiencing chronic groin pain.

Inadvertent bowel injury — Laparoscopic and robotic surgery presents a rare but real risk of inadvertent bowel injury, typically with initial abdominal entry but also with dissection or lysis of adhesions. When it occurs, our preference is repair of the bowel injury, closure of the peritoneal cavity, changing the operating room setup to clean instruments and drapes, and proceeding with an open synthetic mesh repair of the groin hernia.

The most catastrophic complication is a missed bowel injury resulting in delayed presentation, sepsis, and abdominal and surgical site contamination. Any time there is concern for bowel injury, a diligent effort should be undertaken to identify the area of concern, to definitively prove or disprove injury, and to repair any injury if needed. The bowel injury can be identified and repaired through an open, laparoscopic, or robotic approach based upon surgeon experience and comfort.

If a bowel injury occurs, the resulting contamination will raise concern about the risks associated with placement of mesh. No high-quality evidence is available to guide the decision-making; however, considerations in this case include the approach to repair (no repair, open repair, laparoscopic repair, or robotic repair) and repair technique (suture repair, synthetic mesh, or biologic/bioabsorbable mesh). The most conservative options would include no repair (ie, repair bowel injury and return another day to repair the groin hernia) or open suture repair. The most

aggressive options would include laparoscopic or robotic repair with mesh. The decision should be based upon the injury, degree of contamination, complexity of the hernia, and surgeon comfort in this setting.

EVOLVING TECHNIQUES

Total extraperitoneal (TEP) robotic groin hernia repair — The TEP technique is often employed for laparoscopic repairs and is now being adapted for robotic surgery. In this approach, the repair is completed without entering the peritoneal cavity. In brief, the TEP repair involves the use of a balloon dissector to open the preperitoneal space, insufflation to maintain this space, identification of the anatomical landmarks described above, and, lastly, placement of a large piece of mesh. Inadvertent tears in the peritoneum will require repair in order to maintain adequate working space and may require conversion to a transperitoneal approach. Laparoscopically, this approach is associated with a lengthy learning curve. However, robotic surgery may alleviate this issue somewhat as it allows for wristed movements and improved visualization. (See "Laparoscopic inguinal and femoral hernia repair in adults", section on 'Extraperitoneal exposure and dissection'.)

Single-incision robotic groin hernia repair — Although the repair of groin hernias can be accomplished laparoscopically using a single laparoscopic port, this approach is technically challenging due to limited ability to triangulate the instruments in a limited working space. Robotic assistance affords greater ease in the use of instruments through a single port. In a prospective cohort study comparing robotic single-port versus multiport inguinal hernia repair, operative time and recovery time were shorter for the single-port approach, with similar rates of complications, recurrence, and chronic pain [35]. The single-incision platform requires a 2.5 cm periumbilical incision. As a long-term consideration, this larger port size may increase the risk of hernia formation at this port site. (See "Abdominal access techniques used in minimally invasive surgery", section on 'Single-incision laparoscopic surgery'.)

Other robotic platforms — While the da Vinci robotic platform is currently the most widely used system in the world for robotic surgery, several new platforms are emerging and will need to be studied as possible options for minimally invasive hernia surgery. Limited studies exist comparing da Vinci with the other platforms for inguinal hernia repair. The safety and efficacy of these alternative platforms for hernia repair will have to be considered, as well as surgeon factors such as the learning curve and transferability of skills [36,37].

OUTCOMES

Benefit for patients — The RIVAL trial is a randomized trial comparing robotic with standard laparoscopic inguinal hernia repair. This trial demonstrated similar patient-reported outcomes for both approaches, including no differences in postoperative pain levels, quality of life, mobility, cosmesis, and recurrence at up to two years [38,39]. The ROLAIS trial compared robotic with laparoscopic transabdominal preperitoneal (TAPP) inguinal hernia repairs with regard to surgical stress and short-term outcomes, and found lower C-reactive protein and interleukin 6 levels in patients undergoing robotic surgery, as well as shorter operative times, fewer complications, and higher same-day discharge rates [40]. It should be noted, however, that this was a single-center, unblinded study.

Several systematic reviews comparing laparoscopic with robotic groin hernias have been published. One study of over 64,000 patients in nine publications between 2010 and 2021 showed no differences in chronic pain or postoperative complications [41]. Another systematic review of 15 studies through 2023 of over 64,000 patients showed that, in comparison with laparoscopic repair, the robotic approach was associated with longer operative times and higher rates of surgical site infection [42].

Two large database studies draw different conclusions:

- The first study compared five-year outcomes of 150,000 patients in New York State undergoing open, laparoscopic, and robotic inguinal hernia repair [43-45]. Patients undergoing robotic repair had higher rates of comorbidities. Using propensity-for-treatment-adjusted multivariable regression analysis, the authors demonstrated similar outcomes between robotic and laparoscopic repairs and a significantly lower complication rate of robotic repair compared with open repair.

- The second study compared the outcomes of 120,000 patients undergoing inguinal hernia repair using the Veteran Affairs Surgical Quality Improvement Program database [46]. Again, patients undergoing robotic repair had higher rates of comorbidities. On multivariate regression analysis, robotic hernia repair was associated with higher rates of overall, pulmonary, renal, and infectious complications; higher rates of unplanned return to the operating room; longer operative times; and longer length of stay. The use of robotic repair increased from 0.24 percent in 2008 to 19.6 percent in 2019, commensurate with a decrease in complication rate (20.8 percent in 2008 to 3.5 percent in 2019) and a decrease in operative time, suggesting that utilization and outcomes may improve with progression along the learning curve.

In other comparative studies with open or laparoscopic repairs, robotic groin hernia surgery is generally associated with longer or similar operating room time; similar length of hospital stay; and similar 30 day complications, readmissions, and office visits (table 3). A retrospective analysis looked at recurrence rates for laparoscopic versus robotic repairs over an eight-year period and found lower recurrences (0.8 versus 2.9 percent, p = 0.013) and a longer recurrence-free time (99.7 versus 97.6 months) for robotic repairs [47]. Prospective data on the clinically important outcomes of long-term hernia recurrence rate and post-herniorrhaphy neuralgia rate are not yet available. However, it is worth noting that most robotic studies (91 percent) are written by authors with substantial financial conflicts of interest and who receive payments from the robotic industry [48]. Often, the authors do not self-report these conflicts of interest. When authors receive gifts or payments of greater than $10,000 from the robotic industry, they are 200 percent more likely to report beneficial outcomes with robotic surgery (odds ratio 2.07, 95% CI 0.47-3.67, p = 0.011) [49]. Readers are advised to carefully review the conflicts of interest of authors, even investigate the authors' relationships on the Open Payments Database, and interpret the reported results discerningly.

Benefit for surgeons — The 2018 HerniaSurge International Guidelines for groin hernia management concluded that when the surgeon has sufficient experience in the respective surgical techniques, an open mesh repair is similar to laparoscopic repair in terms of recurrence and complication rates [50]. Laparoscopic repair, however, has shorter recovery times and less postoperative pain [4].

Despite this, only 25 percent of groin hernia repairs are performed laparoscopically in the United States [51,52]. Part of the reason for the slow adoption of this procedure is due to the technical challenges of attaining sufficient experience in laparoscopic TAPP and TEP repairs. As an example, it has been estimated that it requires 250 cases to master the laparoscopic TEP technique, while others have reported improvement in outcomes even after 400 repairs [53].

In laparoscopic groin hernia repair, three ports are inserted into the preperitoneal/transversalis fascia planes or peritoneal cavity. Instruments and a camera are introduced via these ports and are controlled directly by the surgeon and an assistant. In robotic groin hernia surgery, the same numbers of ports are inserted into the peritoneal cavity; however, instead of the surgeon and assistant directly controlling the camera, instruments, and ports, the robot is connected to the ports, and robotic instruments and a camera are mounted on the robotic arms into the ports. The surgeon controls the camera and instruments at a remote console that is typically within the same operating suite (picture 3).

In comparison with laparoscopy, the robotic surgical platform affords three-dimensional visualization, wristed movements, and the potential for improved ergonomics [54]. This technology has the potential to overcome the technical challenges of laparoscopic groin hernia repair and allow improved adoption of minimally invasive techniques for groin hernia repair (table 2). Robotic surgery may offer an advantage over laparoscopy for the more technically challenging groin hernias or clinically complex patients [7,47]. However, the potential for improved ergonomics afforded by the robotic platform was not realized in the only trial comparing laparoscopic versus robotic inguinal hernia repair, which rather showed that surgeons had higher frustration levels and increased mental effort when using the robotic technique [38]. However, this trial was conducted by high-volume academic hernia surgeons with substantial expertise in laparoscopic inguinal hernia repair. Experiences among surgeons with a lower volume or in different clinical settings remain to be elucidated.

Cost — Laparoscopic surgery utilizes disposable equipment, including mesh fixation devices, balloon dissectors, and disposable trocars that are not required in robotic surgery. On the other hand, the upfront cost of purchasing a robotic platform (over 1 million USD) and use of limited-reusable robotic-only instruments incurs a charge per use.

Costs were also compared prospectively in the RIVAL trial, which demonstrated higher median costs for the robotic than the laparoscopic approach ($3258 versus $1421, p <0.001) [38]. A 2018 study comparing costs for robotic and laparoscopic inguinal hernia surgery found that the average total cost was significantly higher for robotic surgery ($5517 versus $3269, p <0.001) [55]. The main contributor to this cost difference was significantly longer operative time for robotic cases. This difference in operative times was consistent even when looking at the operative times for the highest-volume surgeons in each group, implying that the difference is not attributable to the learning curve.

The expense of the robotic platform can be affected by current and future choices, including:

- Careful attention to minimizing use of disposable equipment and judicious selection of robotic instruments.
- Building experience and robotic teams to achieve shorter operative times. Robotic surgery depends not just on the surgeon but also upon all members of the surgical team.
- Converting cases from open procedures requiring hospital admission to minimally invasive procedures to avoid or minimize hospital admission.
- Encouraging competition among industry to offer multiple high-quality robotic platforms.

SOCIETY GUIDELINE LINKS

Links to society and government-sponsored guidelines from selected countries and regions around the world are provided separately. (See "Society guideline links: Groin hernia in adults" and "Society guideline links: Minimally invasive general surgery".)

INFORMATION FOR PATIENTS — UpToDate offers two types of patient education materials, "The Basics" and "Beyond the Basics." The Basics patient education pieces are written in plain language, at the 5th to 6th grade reading level, and they answer the four or five key questions a patient might have about a given condition. These articles are best for patients who want a general overview and who prefer short, easy-to-read materials. Beyond the Basics patient education pieces are longer, more sophisticated, and more detailed. These articles are written at the 10th to 12th grade reading level and are best for patients who want in-depth information and are comfortable with some medical jargon.

Here are the patient education articles that are relevant to this topic. We encourage you to print or email these topics to your patients. (You can also locate patient education articles on a variety of subjects by searching on "patient

education" and the keyword(s) of interest.)

- Basics topics (see "Patient education: Groin hernias (The Basics)" and "Patient education: Groin hernia repair (The Basics)" and "Patient education: Groin hernia repair – Discharge instructions (The Basics)")

SUMMARY AND RECOMMENDATIONS

- **Surgical approaches to groin hernia repair** – Groin hernias are a common problem, affecting up to 27 percent of men and 3 percent of women, with 20 million repairs performed annually worldwide. Groin hernias can be repaired via open, conventional laparoscopic, or robot-assisted laparoscopic approaches. While conventional laparoscopic repairs can be performed either totally extraperitoneally (TEP) or transabdominal preperitoneally (TAPP), most robotic repairs are TAPP repairs. (See 'Introduction' above.)

- **Choice of approach for primary hernias** – A minimally invasive approach (conventional laparoscopic or robotic-assisted laparoscopic) is most suitable for patients with obesity, patients at increased risk for surgical site infection (eg, diabetic patients, immunocompromised patients, smokers), patients with recurrence from a prior open repair, bilateral hernias, or femoral/obturator hernias. Given the added costs associated with minimally invasive repair, however, open mesh repair is more appropriate for low-risk patients undergoing the initial repair of a unilateral inguinal hernia. (See 'Primary hernia' above.)

- **Surgical technique** – Our technique of robotic TAPP groin hernia repair is presented in detail and illustrated by this video (movie 1) (see 'Our standard technique' above):

  - Obtaining a view of the myopectineal orifice is an important step in robotic groin hernia repair (picture 2).

  - Mesh should adequately cover all hernia defects with medial overlap to at least the ipsilateral pubic tubercle/Cooper's ligament, lateral coverage to the anterior superior iliac spine, and a posterior (dorsal) edge that is in line with the widely dissected peritoneal reflection. A piece of mesh at least 10 x 15 cm in size is required, while a larger piece (16 x 20 cm) may be used in patients with large direct defects or multiple defects. (See 'Our standard technique' above.)

  - Options for mesh fixation during robotic groin hernia repair include use of a self-fixating mesh, suture fixation, fixation with tacks, application of fibrin sealant, and no fixation. For direct hernia defects larger than 3 cm, we suggest fixing the mesh (**Grade 2C**). In addition, we close direct defects larger than 3 cm with a running barbed suture prior to mesh placement. (See 'Mesh fixation' above.)

  - Laparoscopic and robotic surgery presents a rare but real risk of inadvertent bowel injury, typically with initial abdominal entry but also with dissection or lysis of adhesions. When it occurs, our preference is repair of the bowel injury, closure of the peritoneal cavity, changing the operating room setup to clean instruments and drapes, and proceeding with an open synthetic mesh repair of the groin hernia. (See 'Recurrent hernias' above.)

- **Outcomes**

  - In comparison with open groin hernia repair, robotic surgery is more costly but has similar recurrence rates and may be associated with faster recovery and less pain. In comparison with conventional laparoscopic groin hernia repair, robotic surgery is more costly but has similar rates of recurrences and complications. (See 'Benefit for patients' above.)

- Only 25 percent of groin hernias repairs are performed laparoscopically in the United States. Part of the reason for slow adoption of this procedure is due to the technical challenges of laparoscopic repairs. In comparison to laparoscopy, the robotic surgical platform affords three-dimensional visualization, wristed movements, and improved ergonomics, thereby overcoming some of the technical challenges of laparoscopic groin hernia repair. (See 'Benefit for surgeons' above.)

- In order to reduce operating room costs for robotic cases, attention should be paid to eliminating all unnecessary disposable equipment. (See 'Cost' above.)

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Topic 120860 Version 12.0

GRAPHICS

Table 1: **Antimicrobial prophylaxis for gastrointestinal surgery in adults**

Nature of operation	Common pathogens	Recommended antimicrobials	Usual adult dose*	Redose interval¶
Gastroduodenal surgery				
Procedures involving entry into lumen of gastrointestinal tract	Enteric gram-negative bacilli, gram-positive cocci	Cefazolin[Δ]	<120 kg: 2 g IV ≥120 kg: 3 g IV	4 hours
Procedures not involving entry into lumen of gastrointestinal tract (selective vagotomy, antireflux)	Enteric gram-negative bacilli, gram-positive cocci	High risk[◇] only: cefazolin[Δ]	<120 kg: 2 g IV ≥120 kg: 3 g IV	4 hours
Biliary tract surgery (including pancreatic procedures)				
Open procedure or laparoscopic procedure (high risk)[§]	Enteric gram-negative bacilli, enterococci, clostridia	Cefazolin[Δ¥] (preferred)	<120 kg: 2 g IV ≥120 kg: 3 g IV	4 hours
		or cefotetan	2 g IV	6 hours
		or cefoxitin	2 g IV	2 hours
		or ampicillin-sulbactam	3 g IV	2 hours
Laparoscopic procedure (low risk)	N/A	None	None	None
Appendectomy[‡]				
	Enteric gram-negative bacilli, anaerobes, enterococci	Cefazolin[Δ] **plus** metronidazole (preferred)	*For cefazolin:* <120 kg: 2 g IV ≥120 kg: 3 g IV *For metronidazole:* 500 mg IV	*For cefazolin:* 4 hours *For metronidazole:* N/A
		or cefoxitin[Δ]	2 g IV	2 hours
		or cefotetan[Δ]	2 g IV	6 hours
Small intestine surgery				
Nonobstructed	Enteric gram-negative bacilli, gram-positive cocci	Cefazolin[Δ]	<120 kg: 2 g IV ≥120 kg: 3 g IV	4 hours
Obstructed	Enteric gram-negative bacilli, anaerobes, enterococci	Cefazolin[Δ] **plus** metronidazole (preferred)	*For cefazolin:* <120 kg: 2 g IV ≥120 kg: 3 g IV *For metronidazole:* 500 mg IV	*For cefazolin:* 4 hours *For metronidazole:* N/A
		or cefoxitin[Δ]	2 g IV	2 hours
		or cefotetan[Δ]	2 g IV	6 hours
Hernia repair				

	Aerobic gram-positive organisms	Cefazolin[Δ]	<120 kg: 2 g IV ≥120 kg: 3 g IV	4 hours
Colorectal surgery[†]				
	Enteric gram-negative bacilli, anaerobes, enterococci	Parenteral:		
		Cefazolin[Δ] **plus** metronidazole (preferred)	*For cefazolin:* <120 kg: 2 g IV ≥120 kg: 3 g IV *For metronidazole:* 500 mg IV	*For cefazolin:* 4 hours *For metronidazole:* N/A
		or cefoxitin[Δ]	2 g IV	2 hours
		or cefotetan[Δ]	2 g IV	6 hours
		or ampicillin-sulbactam[Δ,**]	3 g IV (based on combination)	2 hours
		Oral (used in conjunction with mechanical bowel preparation):		
		Neomycin **plus** erythromycin base or metronidazole	¶¶	¶¶

GI: gastrointestinal; IV: intravenous.

* Parenteral prophylactic antimicrobials can be given as a single IV dose begun within 60 minutes before the procedure. If vancomycin or a fluoroquinolone is used, the infusion should be started within 60 to 120 minutes before the initial incision to have adequate tissue levels at the time of incision and to minimize the possibility of an infusion reaction close to the time of induction of anesthesia.

¶ For prolonged procedures (>3 hours) or those with major blood loss or in patients with extensive burns, additional intraoperative doses should be given at intervals 1 to 2 times the half-life of the drug.

Δ For patients allergic to penicillins and cephalosporins, clindamycin (900 mg) or vancomycin (15 mg/kg IV; not to exceed 2 g) with either gentamicin (5 mg/kg IV), ciprofloxacin (400 mg IV), levofloxacin (500 mg IV), or aztreonam (2 g IV) is a reasonable alternative. Metronidazole (500 mg IV) plus an aminoglycoside or fluoroquinolone is also an acceptable alternative regimen, although metronidazole plus aztreonam should not be used, since this regimen does not have aerobic gram-positive activity.

◇ Severe obesity, GI obstruction, decreased gastric acidity or GI motility, gastric bleeding, malignancy or perforation, or immunosuppression.

§ Factors that indicate high risk may include age >70 years, pregnancy, acute cholecystitis, nonfunctioning gallbladder, obstructive jaundice, common bile duct stones, immunosuppression.

¥ Cefotetan, cefoxitin, and ampicillin-sulbactam are reasonable alternatives.

‡ For a ruptured viscus, therapy is often continued for approximately 5 days.

† Use of ertapenem or other carbapenems not recommended due to concerns of resistance.

** Due to increasing resistance of *Escherichia coli* to fluoroquinolones and ampicillin-sulbactam, local sensitivity profiles should be reviewed prior to use.

¶¶ In addition to mechanical bowel preparation, the following oral antibiotic regimen is administered: neomycin (1 g) plus erythromycin base (1 g) **or** neomycin (1 g) plus metronidazole (1 g or 500 mg depending on country and center). The oral regimen should be given as 3 doses over approximately 10 hours the afternoon and evening before the operation. Issues related to mechanical bowel preparation are discussed further separately; refer to the UpToDate topic on overview of colon resection.

Data from:

1. Antimicrobial prophylaxis for surgery. Med Lett Drugs Ther 2016; 58:63.

2. Bratzler DW, Dellinger EP, Olsen KM, et al. Clinical practice guidelines for antimicrobial prophylaxis in surgery. Surg Infec (Larchmt) 2013; 14:73.

Graphic 65369 Version 39.0

Table 2: **Differences and similarities of robotic and laparoscopic groin hernia surgery**

	Laparoscopic TEP	Laparoscopic TAPP	Robotic TAPP
Abdominal entry	Open 12 mm incision to access retrorectus space with balloon dissector	Optical trocar, Veress, or open 12 mm port (Hassan)	Optical trocar, Veress, or open 12 mm port (Hassan)
Number of ports	3	3	3
Port size	2 × 5 mm ports **AND** 1 × 12 mm port (Balloon port)	3 × 5 mm ports **OR** 2 × 5 mm ports **AND** 1 × 11/12 mm port	3 x 8 to 12 mm ports
Port placement	Preperitoneal/pretransversalis fascia (no violation of posterior sheath) Down the lower midline	Intraperitoneal, across the mid abdomen	Intraperitoneal, across the upper abdomen
Laparoscope	12 mm, 30 degree	5 mm, 30 degree	8 or 12 mm, 30 degree
Energy device	None or electrocautery	Electrocautery	Electrocautery
Mesh fixation	None, glue, tacks, or self-fixating mesh	None, glue, tacks, or self-fixating mesh	None, self-fixating mesh, or suture
Peritoneal closure	None needed	Suture	Suture
Port closure (and risk of port-site hernia)	Anterior fascia of the 12 mm port site (low risk for hernia because posterior fascia not violated)	12 mm port site Literature reports 5 to 10% port-site hernia rate at 2 years postoperative[1]	12 mm site Literature reports 5 to 10% port-site hernia rate at 2 years postoperative[1]

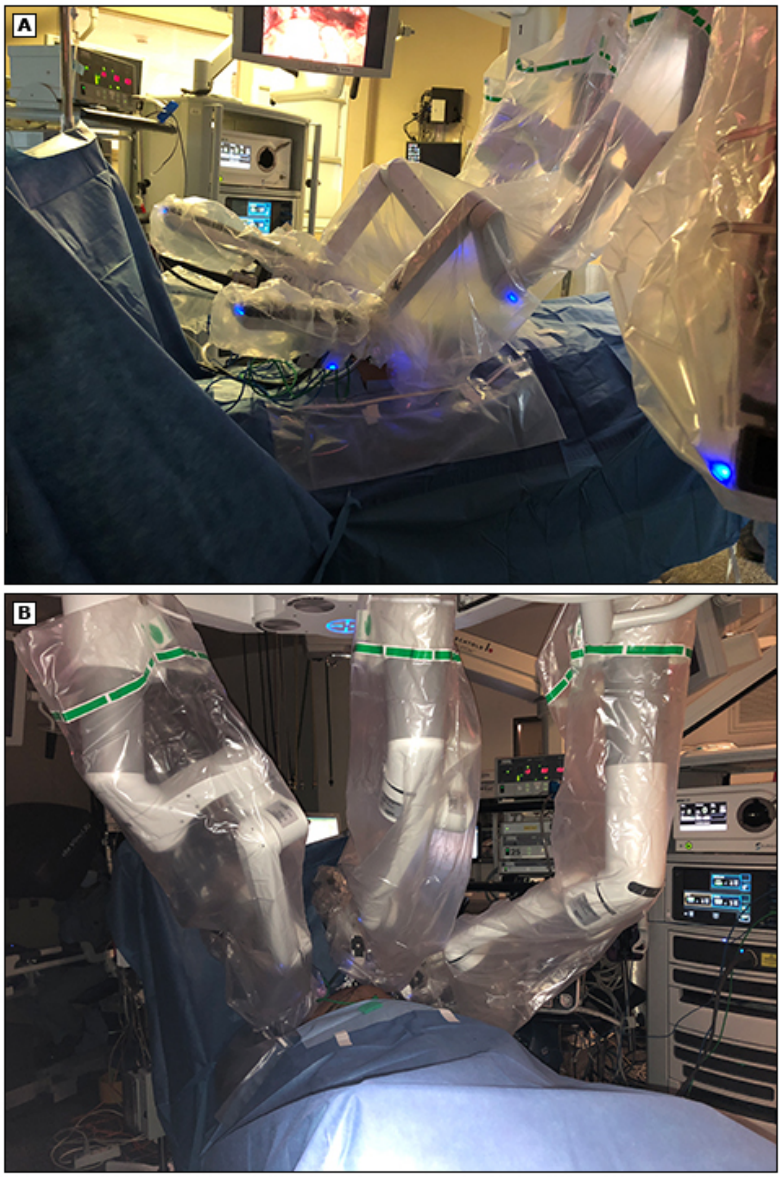
TEP: totally extraperitoneal repair; TAPP: transabdominal preperitoneal repair.

References:

1. Holihan JL, Chen JS, Greenberg J, et al. Incidence of port-site hernias: A survey and literature review. Surg Laparosc Endosc Percutan Tech 2016; 26:425.

Graphic 121186 Version 1.0

Picture 1: **Docking during robotic groin hernia repair**

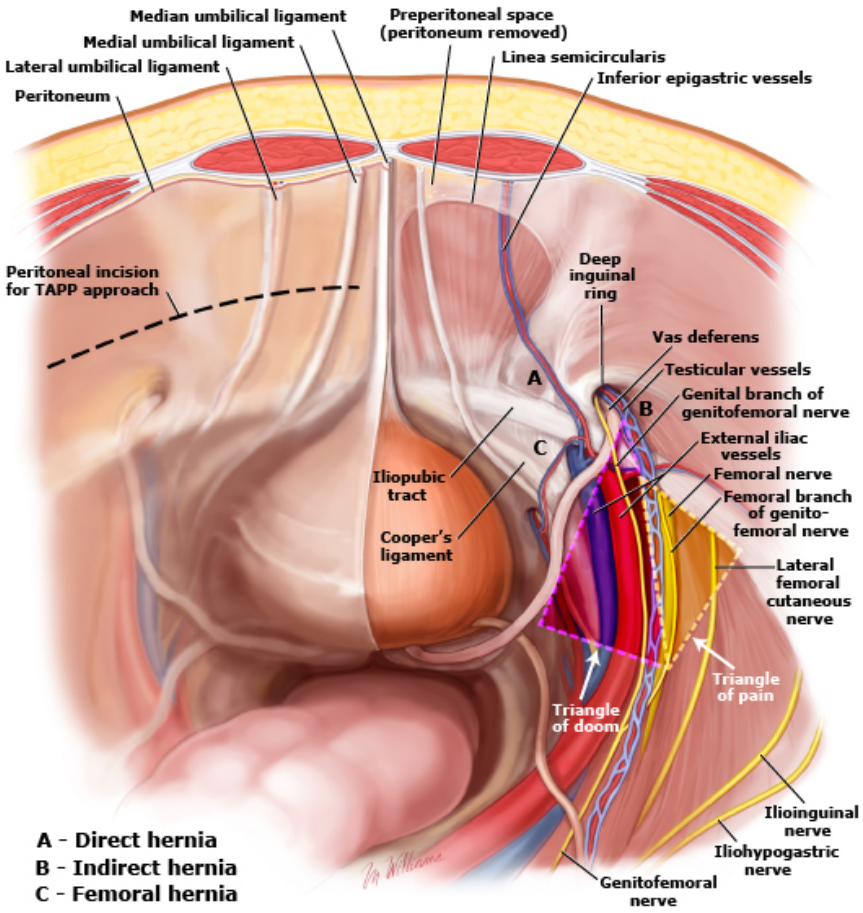


Positioning of the robotic system depends on room setup and the type of platform being utilized. Side docking in parallel or perpendicular is generally used (parallel docking depicted). However, the robot can also be docked in between the legs with the patient in lithotomy position if the room is more amenable to this setup. Docking from either the right or left side of the patient allows for bilateral access and should be chosen based on room setup rather than laterality of the hernia.

Courtesy of Michele M Loor, MD, and Mike K Liang, MD, FACS.

Graphic 121180 Version 2.0

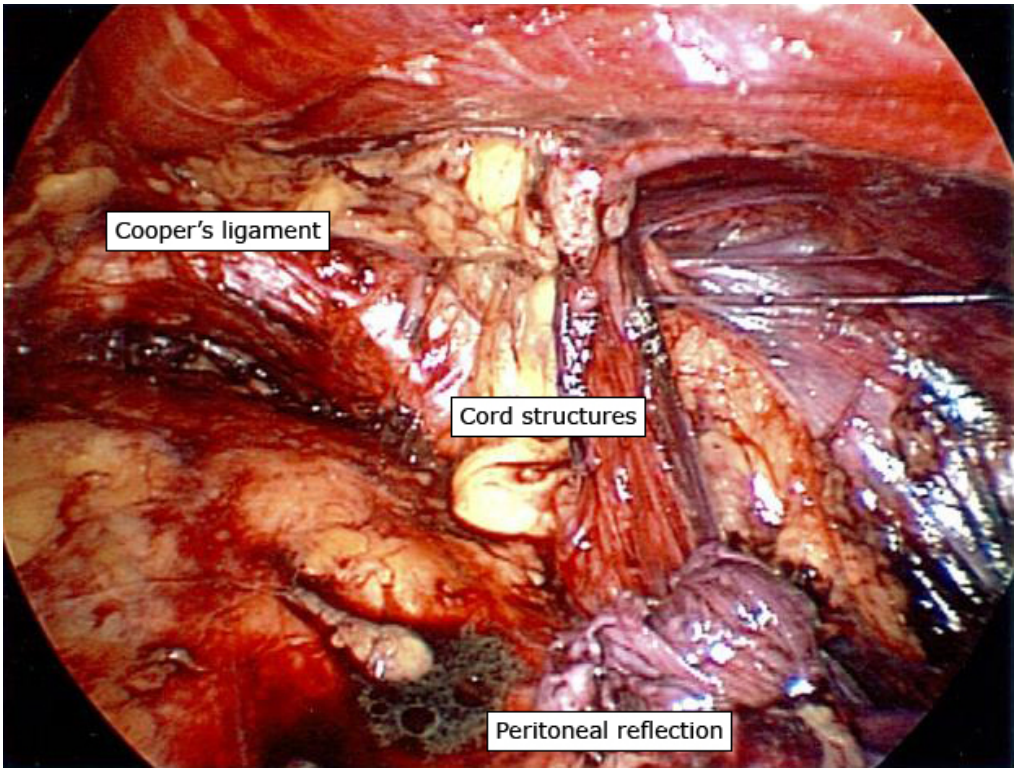
Figure 1: **Laparoscopic view of inguinal anatomy**



TAPP: transabdominal preperitoneal.

Graphic 70359 Version 7.0

Picture 2: **Myopectineal orifice**



In laparoscopic or robotic groin hernia repair, a critical view of the myopectineal orifice has to be obtained before mesh placement. This picture is a sample of that view taken from a robotic right groin hernia repair. Refer to the related UpToDate topic for a detailed description.

Courtesy of Michele M Loor, MD, and Mike K Liang, MD, FACS.

Graphic 121182 Version 1.0

Table 3: **Comparative studies for robotic versus open and/or laparoscopic inguinal hernia repair**

Author Year	COI	Study design	Study	n	Findings			
					Cost	OR time	Complications	Pain, QOL
Holleran TJ et al, 2021[1]	No	Retrospective, large database	O, L, R	O 100,880 L 18,035 R 6063		Longer for R, but improved over study period (2008-2019)	Higher complication rate for R, but improved over study period (2008-2019)	
Tatarian et al, 2021[2]	Yes	Retrospective, large database	O, L, R	O 117,603 L 35,565 R 559			Unadjusted analysis: higher complication and recurrence rate at 5 years for R compared with O and L Propensity score analysis: no difference in outcomes or recurrences at 5 years	
Zhao F et al, 2021[3]	No	Systematic review, meta-analysis	L, R	L 661 R 459		Longer for R	Similar LOS and complication rate for L and R	Similar for L and R
LeBlanc K et al, 2020[4]	Yes	Multicenter, prospective, nonrandomized, propensity matched	L: 19% TAPP; 81% TEP, R, O	L versus R: 80 each; L versus O: 112 each		R longer than O (74.0 versus 51.5 min); R longer than L (83.0 versus 65.0 min)	No difference	Greater need for pain medications in O versus R and L versus R; time to return to normal activities 3 days for R versus 4 days for O; no difference in time to return to normal activities for L versus R; higher QOL R versus O, no difference QOL L versus R
Prabhu AS et al, 2020[5]	Yes	Multicenter, randomized	L-TAPP, R	L 54 R 48	R higher ($3258 versus	R longer (75.5 versus	No difference in wound events or readmissions	No difference

					$1421, p<0.001)	41.5 min, p<0.001)		
Sheldon RR et al, 2019[6]	No	Retrospective	O, L-TEP	R 49 O 9 L 34				No difference in postoperative repeat opiate Rx
Abdelmoaty WF et al, 2018[7]	Yes	Retrospective cost-analysis	L	R 734 L 1671	R higher average cost, lower average variable cost	R longer OR time	No difference in LOS, conversion to open	
Bittner JG et al, 2018[8]	Yes Robotic company employees	Prospective propensity for treatment matched	O, L	R 83 to 85 O 85 L 83				Longer time from IHR to no Rx pain meds with O compared to L, R (p = 0.03); higher groin pain scores at 1 week with O compared to L, R (p<0.01); more activity disruption at 1 week with O compared to L, R (p<0.01)
Charles EJ et al, 2018[9]	Yes	Retrospective, NSQIP database	O, L	R 69 L 241 O 191			No difference in postoperative occurrences, adverse events, readmissions	
Gamagami R et al, 2018[10]	Yes	Retrospective, multicenter	O	R 652 O 602		Longer skin-to-skin times for R (p<0.0001)	No difference in 30 day complications, readmissions, reoperations	
Kolachalam R et al, 2018[11]	Yes	Retrospective propensity for treatment-matched	O	R 95 matched, 148 unadjusted O 93 matched, 113 unadjusted		Longer OR times for R (p<0.0001 unadjusted, p<0.001 matched)	Increased post-discharge complications to 30 days for O (p = 0.005 unadjusted, p = 0.047 matched)	
Kosturakis AK et al, 2018[12]	No	Retrospective case-matched	O	R 100 O 100		No difference in OR times		More multiple postoperative

								visits for pain for O IHR (p = 0.003)
Muysoms F et al, 2018[13]	Yes	Observational case control	L-TAPP	R 49 L 64		No difference in OR time after learning curve	No difference in complications	
Kudsi OY et al, 2017[14]	Yes	Retrospective single surgeon	L-TEP	R 118 L 157		No difference	No difference in 30 day complications	
Waite KE et al, 2016[15]	No	Retrospective	L-TAPP	R 39 L 24	Cost per case was similar L and R when results separated into unilateral versus bilateral	Longer OR time for R (p<0.001 for unilateral, p = 0.004 for bilateral)		Recovery time, average pain were similar L and R when results separated into unilateral versus bilateral

COI: conflicts of interest; OR: operating room; QOL: quality of life; O: open; L: laparoscopic; R: robotic; LOS: length of stay; TAPP: transabdominal preperitoneal; TEP: totally extraperitoneal; L-TAPP: laparoscopic transabdominal preperitoneal; L-TEP: laparoscopic totally extraperitoneal; IHR: inguinal hernia repair; NSQIP: National Surgical Quality Improvement Program.

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1. *Holleran TJ, Napolitano MA, Sparks AD, et al. Trends and outcomes of open, laparoscopic, and robotic inguinal hernia repair in the veterans affairs system. Hernia 2021.*
2. *Tatarian T, Nie L, McPartland C, et al. Comparative perioperative and 5-year outcomes of robotic and laparoscopic or open inguinal hernia repair: A study of 153,727 patients in the state of New York. Surg Endosc 2021.*
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Picture 3: **Robotic OR and platform for groin hernia repair**

In robotic groin hernia surgery, the robot is connected to the ports and robotic instruments and camera are mounted on the robotic arms into the ports. The surgeon controls the camera and instruments at a remote console that is typically within the same operating suite.

OR: operating room.

Courtesy of Michele M Loor, MD, and Mike K Liang, MD, FACS.

Graphic 121184 Version 1.0

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