Since its first description in 1990, laparoscopic inguinal herniorrhaphy has shown a great deal of promise; however, concurrently with its development, open anterior herniorrhaphy has evolved into a tension-free, mesh repair that is easily performed with the patient under local anesthesia and that is also associated with rapid recovery and low recurrence rates [see 5:27 Open Hernia Repair]. Thus, the key question about laparoscopic inguinal hernia repair at present is whether it provides a significant advantage over the tension-free open repair now in use.

The two most common techniques for laparoscopic inguinal hernia repair involve the insertion of mesh into the preperitoneal space; one makes use of a transabdominal preperitoneal (TAPP) approach, the other a totally extraperitoneal (TEP) approach. Both approaches would appear to offer potential advantages, such as reduced postoperative pain, shortened recovery, quicker and more accurate assessment and repair of bilateral groin hernias simultaneously, and, in the case of recurrent hernia, avoidance of previously dissected and technically difficult scarred areas. In practice, however, the advantages are not invariably realized; a laparoscopic approach is not always minimally invasive, and various disadvantages accrue from the current requirement for general anesthesia, the need to traverse the abdominal cavity in the TAPP technique, and the increase in operating room time and costs.

Meticulous attention to surgical technique is essential. Because surgeons may be unfamiliar with inguinal anatomy as viewed from inside the abdomen and because the potential for complication necessitating laparotomy is increased with the laparoscopic approach, surgeons must be proficient in laparoscopic techniques and must have a precise knowledge of anatomic relations in the region of the groin as seen from the peritoneal surface.

Since the late 1990s, laparoscopic video techniques have also been increasingly applied to the repair of incisional hernias. Laparoscopic repair of large incisional hernias resembles open repair in that mesh is inserted to cover the defect in the abdominal wall fascia [see 5:27 Open Hernia Repair]. A laparoscopic approach is theoretically attractive because an open approach usually necessitates a large incision as well as extensive and tedious wide dissection to expose the abdominal wall defect, resulting in considerable postoperative pain and a risk of wound complications—problems that a laparoscopic approach to the defect from within might minimize.

It may be many more years before the true safety and efficacy of laparoscopic herniorrhaphy can be determined and the correct indications for its use established. In the meantime, every repair performed should be subjected to careful classification, documentation, and quality-of-life assessment. Surgeons should not perform laparoscopic herniorrhaphy simply because it is relatively new or potentially economically; they should perform it only when convinced that it is anatomically and physiologically correct and logical.

In what follows, we discuss laparoscopic repair of both inguinal and incisional hernias. In addition to describing current operative techniques, we address inguinal surgical anatomy, preoperative planning, and complications. Finally, we review selected trials measuring the results of laparoscopic repair against those of open repair and comparing the outcomes of TAPP repair with those of TEP repair.
pelvic brim and falls into the pelvis and behind the bladder. There is a small artery that runs with the vas deferens and is not well seen or known. It is white and cordlike in appearance and can usually be seen just beneath the peritoneum.

**Obliterated Umbilical Artery**

The obliterated umbilical artery is an unfamiliar but sometimes prominent structure that is seen in the TAPP approach. It courses along the anterior abdominal wall toward the umbilicus, often with an apparent mesentery. It is most prominent in the region of the medial inguinal space. This ligament is most readily identified when the umbilical laparoscope is directed toward the pelvic midline, where the ligament’s bilateral structure is best seen as it is oriented toward the umbilicus. Medial retraction of this structure is usually necessary for full exposure of the medial aspect of the inguinal canal.

**Inferior Epigastric Vessels**

The inferior epigastric artery and vein lie in the medial aspect of the internal inguinal ring and ascend the inferior surface of the rectus abdominis. In the TAPP approach, these vessels may be difficult to visualize, particularly in obese patients. They are best identified by locating the internal inguinal ring at the junction of the vas deferens and the testicular artery and vein. At this location, the vessels exit the medial margin of the internal ring. However, they can quickly fade from view as they travel superiorly and medially along the anterior abdominal wall. In the TEP approach, early identification of the inferior epigastric vessels helps guide lateral dissection and identification of the internal ring [see Figure 3]. However, dissection in the incorrect plane when the preperitoneal space is initially established may strip these vessels off the abdominal wall.

**External Iliac Vessels**

The lateral spermatic vessels and the medial vas deferens merge at the internal inguinal ring and enter the inguinal canal, where they form the apex of the so-called triangle of doom [see Figure 4a, insert]. Beneath this triangle lie the external iliac artery and the external iliac vein. More laterally, the femoral nerve can be found. The external iliac vessels are often difficult to visualize, though in an elderly patient, a calcified pulsating artery may be prominent. Extreme care must be taken not to dissect within the triangle of doom, because such dissection can result in serious bleeding.

**Cooper’s Ligament**

Cooper’s ligament is a condensation of the transversalis fascia and the periosteum of the superior pubic ramus lateral to the pubic tubercle. It can be seen only in the preperitoneal space and is the first landmark that should be identified during a TEP repair. In the initial stages of a TAPP repair, with the peritoneum intact, it is often easier to palpate the ligament than to see it, but once the ligament has been identified and cleaned, its glistening white fibers are apparent. Care must be taken during dissection to avoid the tiny branches of the obturator vein that often run along the ligament’s surface. The iliopubic tract inserts into the superior ramus of the pubis just lateral to Cooper’s ligament, blending into it.
**Internal Inguinal Ring**

In the TAPP approach, the internal inguinal ring is normally identified by a slight indentation of the peritoneum at the junction of the vas deferens and the spermatic vessels. When an indirect hernia is present, however, a true ring or opening is easily identified, and by rotating a 30° laparoscope, the surgeon can look directly into the hernial sac or insert the laparoscope into the sac, which often allows the external inguinal ring to be identified more medially. An indirect hernial sac lies anterior and lateral to the spermatic cord at this level, as opposed to the familiar medial cord position seen in the classic exterior groin approach to open herniorrhaphy. The medial border of the internal inguinal ring is formed by the transversalis fascia and the inferior epigastric vessels. The inferior border is formed by the iliopubic tract, a distinct structure that is the internal counterpart of the inguinal ligament. Anteriorly, the internal inguinal ring is bordered by the transversus abdominis arch, which passes laterally over the internal ring and forms a very well defined visible edge. The layers of the abdominal wall constituting the lateral border of the internal inguinal ring appear the same as when viewed from the exterior approach, and this border, like all margins of the internal inguinal ring, is visible only when an indirect hernia is present.

**Iliopubic Tract**

The iliopubic tract originates laterally from the anterior superior spine of the ilium and courses medially, forming the inferior margin of the internal inguinal ring and the roof of the femoral canal before inserting medially into the superior pubic ramus. This tract is formed by the condensation of the transversalis fascia with the most inferior portion of the transversus abdominis muscle and aponeurosis, and it is usually sturdy along its entire course. All inguinal hernia defects lie above the iliopubic tract, either anterior or superior to it. Conversely, femoral hernias occur below the tract, either posterior or inferior to it. Fibers of the iliopubic tract extend into Cooper’s ligament medially, where they become the medial margin of the femoral canal. The iliopubic tract is frequently confused with the inguinal ligament. This ligament, though nearby, is part of the superficial musculoaponeurotic layer, which is not seen laparoscopically, whereas the iliopubic tract is part of the deep layer.

**Femoral Canal**

The femoral canal is seen only in the presence of a femoral hernia in the most medial aspect of the femoral triangle. The anterior and medial borders are formed by the iliopubic tract, the posterior or border is formed by the pectineal fascia, and the lateral border is formed by the femoral sheath and vein.

**Trapezoid of Disaster**

Another area worthy of careful attention is the so-called trapezoid of disaster, containing the genitofemoral, ilioinguinal, iliohypogastric, and lateral cutaneous nerves of the thigh, which innervate the spermatic cord, the testicle, the scrotum, and the upper and lateral thigh, respectively. A detailed knowledge of the anatomical courses of the nerves and careful avoidance of these structures during dissection are essential [see Figure 4].

**Genitofemoral nerve** The genitofemoral nerve arises from the first and second lumbar nerves; pierces the psoas muscle and fascia at its medial border opposite L3 or L4; descends under the peritoneum, on the psoas major; and divides into a medial genital and a lateral femoral branch. The femoral branch descends lateral to the external iliac artery and spermatic cord, passing posteroinferior to the iliopubic tract and into the femoral sheath to supply the skin over the femoral triangle. The genital branch crosses the lower end of the external iliac artery and enters the inguinal canal through the internal inguinal ring with the testicular vessels. This branch supplies the coverings of the spermatic cord down to the skin of the scrotum. The genitofemoral nerve is the most visible of the cutaneous nerves and is sometimes confused with the testicular vessels if the latter are not well appreciated in their more medial position.

**Ilioinguinal and iliohypogastric nerves** When dissected from the anterior position, the ilioinguinal and iliohypogastric nerves lie between the external oblique and the internal oblique muscles above the internal inguinal ring and descend with the spermatic cord. In the abdomen, the ilioinguinal and iliohypogastric nerves arise from the 12th thoracic and first lumbar nerve roots, are more laterally located, and run subperitoneally, emerging from the lateral psoas border to pierce the transverse abdominis near the iliac crest, then piercing and coursing between the
internal oblique and the external oblique muscles close to the internal inguinal ring. Aberrant branches sometimes descend with the genital nerve. The ilioinguinal nerve supplies a small cutaneous area near the external genitals.

**Lateral cutaneous nerve of thigh** Supplying the front and lateral aspect of the thigh, the lateral cutaneous nerve of the thigh arises from the second and third lumbar nerves and emerges at the lateral border of the psoas. There, it descends deep to the peritoneum on the iliac muscle and only comes to lie in a superficial position 3 cm below the anterosuperior iliac spine.

**PREOPERATIVE EVALUATION**

**History and Physical Examination**

Preoperative assessment is necessary to determine whether a patient is a suitable candidate for laparoscopic herniorrhaphy. A careful surgical history, including both previous hernia repairs and
other procedures (particularly those involving the lower abdomen), should be elicited. A cardiovascular history should also be obtained and risk factors for general anesthesia determined.

Physical examination should confirm the presence of an inguinal hernia. If the patient reports a history of a bulge but no hernia is felt on physical examination, an occult hernia may be presumed. Ultrasonography may be helpful for distinguishing an incarcerated groin hernia from other causes of inguinal swelling (e.g., lymphadenopathy or venous varix).

Selection of Patients

Indications With the evolution of the open anterior approach to tension-free prosthetic mesh repair, determining which patients will benefit significantly from laparoscopic herniorrhaphy has become increasingly important. In 2003, the Cochrane Database of Systemic Reviews published an update to its original 2000 report on laparoscopic versus open techniques for hernia repair, which indicated that whereas laparoscopic repairs (TAPP and TEP) generally took longer and had a higher rate of more serious complications (bowel, bladder, and vascular injuries) than open repairs, they also were associated with shorter recovery times and a lower incidence of persistent pain and numbness. Reduced hernia recurrence was related to the use of mesh rather than to operative technique. The overall risk of recurrence with the laparoscopic approach may be related to the surgeon’s level of experience. We believe that patients are best served when a surgeon has several approaches at his or her command that can be applied to and, if necessary, modified for individual circumstances.

Currently, we treat primary unilateral hernias with an open anterior mesh repair, preferably with the patient under local or regional anesthesia; possible exceptions include manual laborers and athletes who desire a rapid return to vigorous physical activity. We generally reserve laparoscopic inguinal herniorrhaphy for the following clinical situations:

1. Recurrent hernia after previous anterior repair. In such cases, a laparoscopic approach allows the surgeon to avoid the scar tissue and distorted anatomy present in the anterior or abdominal wall by performing the repair through unviolated tissue, thereby potentially reducing the risk of damage to the vas deferens or the testicular vessels. This is especially true when mesh has previously been placed anteriorly.
2. Bilateral hernias or a unilateral hernia when the presence of a contralateral hernia is strongly suspected. In such cases, a laparoscopic approach allows the surgeon to repair the two hernias simultaneously (and perhaps more rapidly) without having to make additional incisions.
3. Repair of an inguinal hernia concurrent with another laparoscopic procedure, provided that there is no contamination of the peritoneal cavity.

The choice of laparoscopic technique depends on the patient’s history and on the type of hernia present. In general, we favor TEP repair for most patients because it does not involve entry into the abdominal cavity. The TEP approach reduces the risk of complications affecting intra-abdominal structures, theoretically decreases the risk of adhesions, maintains an intact peritoneal layer between the mesh and the intra-abdominal contents, and allows the mesh to be placed without the use of fixation. However, it has a steeper learning curve than TAPP does, and it may not be feasible in patients who have undergone lower abdominal procedures.

Contraindications We do not treat acutely incarcerated hernias laparoscopically. In patients to whom general anesthesia may pose an increased risk, we prefer open anterior repair using local or regional anesthesia. In infants and young children with indirect hernias, for whom repair of the posterior canal wall is unnecessary, we recommend high ligation of the sac via the anterior approach.

Previous lower abdominal surgery, though not an absolute contraindication, may make laparoscopic dissection difficult. In particular, with respect to TEP repair, previous lower abdominal wall incisions may make it impossible to safely separate the peritoneum from the abdominal parietes for entry into the extraperitoneal plane, and conversion to a TAPP repair or an open repair may be required. Previous surgery in the retropubic space of Retzius, as in prostatic procedures, is a relative contraindication that is associated with an increased risk of bladder injury and other complications. Similarly, previous pelvic irradiation may preclude safe dissection of the peritoneum from the abdominal wall.

Operative Planning

Preparation

General anesthesia is administered routinely. Prophylactic antibiotics are unnecessary. The patient is instructed to void before surgery, which renders bladder catheterization unnecessary.

Patient Positioning

The patient is placed in the supine position with both arms tucked against the sides. The anesthesia screen is placed as far toward the head of the table as possible to allow the surgeon a wide range of mobility with the laparoscope. The skin is prepared and draped so as to allow exposure of the entire lower abdomen, the genital region, and the upper thighs because manipulation of the hernial sac and the scrotum may be necessary. After the laparoscope has been introduced, the patient is placed in a deep Trendelenburg position so that the viscera will fall away from the inguinal areas. Further bowel manipulation is rarely necessary, except to reduce hernial contents. Rotation of the table to elevate the side of the hernia can provide additional exposure, if necessary. A single video monitor is placed at the foot of the bed, directly facing the patient’s head.

The surgeon usually begins the repair while standing on the side contralateral to the defect; the assistant surgeon stands opposite the surgeon, and the nurse stands on the ipsilateral side (see Figure 5). A two-handed operating technique provides a distinct technical advantage.

Equipment

Because inguinal hernias occur in the anterior abdominal wall, visualization through the umbilicus requires that the laparoscope be angled close to the horizontal plane. The view is paralleled anteriorly by the surface of the lower abdominal wall, which may make visualization with a 0° laparoscope difficult. In addition, an indirect hernia is a three-dimensional tubular defect that can be well visualized in its entirety only with an angled lens. For these reasons, we recommend routine use of an oblique, forward-viewing 30° or 45° laparoscope. Excellent laparoscopes are currently available in 10 mm and 5 mm sizes. For the TAPP repair, one 10/12 mm and two 5 mm trocars are used. The dissection is performed with a dissecting scissors, to which an electrocautery may be attached. For mesh fixation, we currently use a spiral tacker (TACKER; U.S. Surgical Inc., Norwalk, Connecticut).

In a TEP repair, besides the equipment needed for a TAPP repair, a balloon-tipped blunt trocar is used to gain access to the preperitoneal space. We usually develop the preperitoneal space with a balloon system (see Operative Technique, Totally Extraperitoneal Hernia Repair).
Two additional 5 mm trocars are placed. The dissection is performed with two blunt-tipped dissectors.

**OPERATIVE TECHNIQUE**

**Totally Extrapерitoneal Repair**

The extra-abdominal preperitoneal approach to laparoscopic hernia repair, developed by McKernan,20,21 attempts to duplicate the open preperitoneal repair described by Stoppa22-24 and Wantz.12,25 In a TEP repair, the trocars are placed preperitoneally in a space created between the fascia and the peritoneum. Ideally, the dissection remains in the extra-abdominal plane at all times, and the peritoneum is never penetrated.

**Step 1: creation of preperitoneal space**

With the patient in the Trendelenburg position, the anterior rectus fascia is opened through a 1 cm infraumbilical transverse incision placed slightly toward the side of the hernia, which helps prevent inadvertent opening of the peritoneum. An index finger is inserted on the medial aspect of the exposed rectus abdominis and slid over the posterior rectus sheath. In this plane, a preperitoneal tunnel between the recti abdominis and the peritoneum is created in the midline by inserting a Kelly forceps (with the tips up) and performing gentle blunt dissection to the level of the symphysis pubis. A blunt 10/12 mm trocar is then secured in the preperitoneal space with fascial stay sutures.

A 30° or 45° operating laparoscope is inserted into the trocar for visualization of the development of the correct plane while insufflation of the preperitoneal space is begun, with the recti abdominis seen anteriorly and the peritoneum posteriorly. Maximal inflation pressure is 10 to 12 mm Hg to prevent disruption of the peritoneum or development of extensive subcutaneous emphysema. Blunt gentle dissection with the laparoscope is employed to develop the space sufficiently to allow placement of additional trocars.

An alternative approach to dissection of the preperitoneal space—one that is especially helpful early in a surgeon’s experience—is to employ a preperitoneal distention balloon system (e.g., PDB; U.S. Surgical Inc., Norwalk, Connecticut). This system consists of a trocar with an inflatable balloon at its tip, which is used to develop the preperitoneal space by atraumatically separating the peritoneum from the abdominal wall. The balloon is

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**Figure 5** Laparoscopic inguinal hernia repair. Shown is one of several possible OR setups. The surgeon stands on the side contralateral to the defect, with a nurse on the ipsilateral side. The assistant surgeon stands opposite the surgeon. This positioning may vary, depending on the surgeon's preference and handedness, the visibility of the defect, and the type of defect present, as well as on the prominence of the medial umbilical ligament and the need for its retraction.

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**Figure 6** Laparoscopic inguinal hernia repair: TEP approach. Shown is the preperitoneal distention balloon (PDB) system. The PDB is introduced into the preperitoneal space (a). As it is tunneled inferiorly toward the pubis, the PDB is inflated under laparoscopic vision (b). Once the preperitoneal space is created, the PDB is removed and replaced with a blunt-tip trocar. The preperitoneal space is insufflated under low pressure, additional trocars are placed, and the repair is completed (c).
inserted into the preperitoneal space below the umbilicus by means of an open Hasson technique and is tunneled inferiorly toward the pubis until the bone is felt with the tip of the balloon trocar. With the laparoscope in the trocar, the preperitoneal working space is developed by gradual inflation of the balloon to a volume of 1 L; the transparency of the balloon permits constant laparoscopic visualization throughout the distention process. Once the working space is created, the PDB is removed and replaced with a blunt sealing trocar. S-retractors are used to elevate the rectus and help ensure correct positioning of the trocar above the posterior fascia. The preperitoneal space is then reinsufflated to a pressure of 10 to 12 mm Hg [see Figure 6].

**Step 2: trocar placement** After the peritoneum is dissected away from the rectus abdominis, a midline 5 mm trocar is inserted under direct vision three fingerbreadths below the infraumbilical port. A second 5 mm trocar is then inserted another three fingerbreadths below the first 5 mm trocar. Placement of the working trocars away from the pubis facilitates mesh placement, in that the bottom port is not covered by the top of the mesh and thereby rendered nonfunctional [see Figure 7]. Care must be taken not to penetrate the peritoneum during trocar placement. If the peritoneum is penetrated, the resulting pneumoperitoneum can reduce the already limited working space. If the working space is compromised to the point where the repair cannot continue (which is not always the case), the surgeon can either try to repair the rent with a suture or place a Veress needle in the upper abdominal peritoneal cavity. If such maneuvers are unsuccessful, the loss of working space may necessitate conversion to a TAPP approach.

**Step 3: dissection of hernial sac** Wide dissection of the preperitoneal space is then undertaken with blunt graspers in a two-handed technique by bluntly dividing the avascular areolar tissue between the peritoneum and the abdominal wall [see Figure 8]. The pubis, Cooper’s ligament, and the inferior epigastric vessels are located first and used to orient the dissection. If a direct hernia is present medial to the inferior epigastric vessels, it will often be reduced by the balloon dissector [see Figure 9]. If not, the sac and the preperitoneal contents are carefully dissected away from the fascial defect and swept cephalad as far as possible. Gentle traction is applied to expose and dissect away the attachment of the peritoneum to the transversalis fascia [see Figure 10].

The indirect space is then exposed by sweeping off the tissue lateral to the inferior epigastric vessels until the peritoneum is found. If a lipoma of the cord is present, it will be lateral to and covering the peritoneum and should be dissected out of the internal ring in a cephalad direction to prevent it from displacing the mesh.18 If there is no indirect hernia, the peritoneum will be found cephalad to the internal ring. To ensure secure mesh placement, the peritoneum is bluntly dissected off the cord structures and placed as far cephalad as possible.
Figure 10 Laparoscopic inguinal hernia repair: TEP approach. The transversalis fascia is seen adherent to the hernial sac. The sac must be separated from the fascia and dissected cephalad to the level of the umbilicus.

If an indirect hernia is present, the sac will be lateral and anterior to the cord structures. A small indirect hernial sac is bluntly dissected off the spermatic cord with a hand-over-hand technique and reduced until an area sufficient for mesh placement is created [see Figure 11]. To prevent early recurrence, all attachments of the peritoneum should be dissected cephalad to where the inferior edge of the mesh will be. If a large indirect sac is not easily reduced from the scrotum, it may be transected in its superolateral edge, dissected off the cord structures, and closed with an endoscopic ligating loop. The distal sac is then left in place and not ligated.

Unlike a TAPP repair, in which any indirect hernia present is readily apparent at first inspection, a TEP repair always requires that the space lateral to the inferior epigastric vessels be dissected to make sure that there is no indirect component. This dissection should be done even if a direct or femoral hernia is identified. The medial border of dissection is the iliac vein or its overlying fat, and the lateral border of dissection is the psoas muscle. Superiorly, dissection should reach the level of the umbilicus.

Step 4: placement of mesh As a rule, we use a large (10.8 × 16 cm) piece of polypropylene mesh shaped to the contours of the inguinal region. A number of different products can also be used for this purpose, including various forms of polypropylene and several types of polyester. A marking suture is placed at the superior edge of the mesh on the concave side, which is to be apposed to the peritoneum. The mesh is wrapped around a grasper in a tubular fashion, then inserted through the umbilical trocar into the preperitoneal space. Once in the preperitoneal space, the mesh is manipulated to cover the pubic tubercle, the internal ring, Cooper’s ligament, the femoral canal, and the rectus abdominis superiorly [see Figure 12]. Tacks or sutures are not usually needed for fixation, but if they are used, they should be placed into Cooper's ligament and the anterior abdominal wall; to prevent nerve injury, no tacks should be placed inferior to the iliopectineus tract lateral to the internal ring. Some surgeons believe that with direct hernias, there is a risk that the mesh may migrate into a large defect. Accordingly, they place several tacks into Cooper's ligament to prevent this occurrence. For bilateral hernias, two identical repairs are done, and two mesh patches are used.

Step 5: closure The operative site is inspected for hemostasis. The trocars are removed under direct vision. The insufflated CO₂ is slowly released so that the mesh may be visualized as the preperitoneal fat and contents collapse back onto the mesh. The fascia at trocar sites 10 mm or larger is closed with 2-0 polydioxanone sutures, and the skin is closed with subcuticular sutures.

Transabdominal Preperitoneal Repair

Step 1: placement of trocars Pneumoperitoneum is established through a small infraumbilical incision. We generally prefer an open technique, in which a blunt-tipped 12 mm trocar is inserted into the peritoneal cavity under direct vision. CO₂ is then insufflated into the abdomen to a pressure of 12 to 15 mm Hg. The angled laparoscope is introduced, and both inguinal areas are inspected. Two 5 mm ports are placed, one at the lateral border of each rectus abdominis at the level of the umbilicus, to allow placement of the camera and the instruments [see Figure 13]. The 5 mm lateral ports may be replaced with 10 mm ports if only a 10 mm laparoscope is available.

Step 2: identification of anatomic landmarks The four key anatomic landmarks mentioned earlier [see Laparoscopic Inguinal Hernia Repair, Anatomic Considerations, above]—the spermatic vessels, the obliterated umbilical artery (medial umbilical ligament), the inferior epigastric vessels (lateral umbilical ligament), and the external iliac vessels—are identified on each side.

In the presence of an indirect hernia, the internal inguinal ring is easily identified by the presence of a discrete hole lateral to the junction of the vas deferens, the testicular vessels, and the inferior epigastric vessels. Identification of a direct hernia can be more difficult. Sometimes, a direct hernia appears as a complete circle or hole; at other times, it appears as a cleft, medial to the vas deferens–vascular junction; and at still other times, it is completely hidden by preperitoneal fat and the bladder and umbilical ligaments. Visualization can be particularly difficult in obese patients, who may have considerable lipomatous tissue between the peritoneum and the transversalis fascia, or in patients whose hernia consists of a weakness and bulging of the entire inguinal floor rather than a distinct sac. For adequate definition of this type of hernia and deeper anatomic structures, the peritoneum must be opened, a peritoneal flap developed, and the underlying fatty layer dissected. Direct hernial defects are often situated...
medial to the ipsilateral umbilical ligament, and retraction or even division of this structure is sometimes necessary. Division of this structure has no negative sequelae; however, the surgeon should be aware that the obliterated umbilical artery may still be patent and that use of the electrocautery or clips may be necessary. Traction on the ipsilateral testicle can demonstrate the vas deferens when visualization is obscured by overlying fat or pressure from the pneumoperitoneum.

**Step 3: creation of peritoneal flap** The curved scissors or the hook cautery is used to create a peritoneal flap by making a transverse incision along the peritoneum, beginning 2 cm above the upper border of the internal inguinal ring and extending medially above the pubic tubercle and laterally 5 cm beyond the internal inguinal ring [see Figure 14]. Extreme care must be taken to avoid the inferior epigastric vessels. Bleeding from these vessels can usually be controlled by cauteryization, but application of hemostatic clips may be necessary on occasion. Another solution is to pass percutaneously placed sutures above and below the bleeding point while applying pressure to the bleeding vessel so as not to obscure the field of vision. If the monopolar cautery is used to create the peritoneal flap, the entire uninsulated portion of the instrument must be visible at all times to ensure that inadvertent bowel injury does not occur.

The incised peritoneum is grasped along with the attached preperitoneal fat and the peritoneal sac and is dissected cephalad with blunt and sharp instruments to create a lower peritoneal flap [see Figure 15]. Dissection must stay close to the abdominal wall. A significant amount of preperitoneal fat may be encountered, and this should remain with the peritoneal flap so that the abdominal wall is cleared. When the correct preperitoneal plane is entered, dissection is almost bloodless and is easily carried out.

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**Figure 12** Laparoscopic inguinal hernia repair: TEP approach. The mesh is oriented so as to cover the indirect, direct, and femoral spaces (inguinal floor). The dissected hernial sac is placed over the top of the mesh to reduce the risk that the sac will slide underneath the mesh and cause a recurrence of the hernia.

**Figure 13** Laparoscopic inguinal hernia repair: TAPP approach. Shown is standard trocar placement for TAPP repair. Usually, three trocar sites are used. The laparoscope is inserted through the umbilical trocar, and two additional trocars are placed in the right and the left midabdomen. To ensure that the first trocar is not placed too close to the surgical field, the first trocar should be placed either in the umbilicus or immediately above it. The two lateral trocars should be placed lateral to the rectus sheath to prevent bleeding and postoperative muscle spasm. At least one trocar must be 10/12 mm to allow insertion of the mesh.

**Figure 14** Laparoscopic inguinal hernia repair: TAPP approach. Shown is dissection of a left direct inguinal hernia. The hernial sac is inverted and the peritoneum incised superior to the sac.

**Figure 15** Laparoscopic inguinal hernia repair: TAPP approach. A flap of peritoneum is dissected downward, revealing a hernial defect and the inferior epigastric vessels (arrow) on the left side.
Laparoscopic inguinal hernia repair: TAPP approach. Dissection of the preperitoneal space on the left side allows identification of the iliopubic tract inferior to the direct hernial defect.

Step 4: dissection of hernial sac: The hernial sac, if present, is removed from Hesselbach’s triangle or the spermatic cord and surrounding muscle through inward traction, counterraction, and blunt dissection with progressive inversion of the sac until the musculofascial boundary of the internal inguinal ring and the key deep anatomic structures are identified. In most cases, the hernial sac can be slowly drawn away from the transversalis fascia or the spermatic cord. The sac is grasped at its apex and pulled inward, thus being reduced by inversion. The indirect sac may be visualized more easily if it is grasped and retracted medially; this step facilitates its dissection away from the cord structures.

Spermatic cord lipomas usually lie posterolaterally and are extensions of preperitoneal fat. In the presence of an indirect defect, such lipomas should be dissected off the cord along with the peritoneal flap to lie cephalad to the internal inguinal ring and the subsequent repair so that prolapse through the ring can be prevented.

A large indirect hernial sac can be divided at the internal ring if it cannot be readily dissected away from the cord structures. This step may prevent the type of cord injury that can result from extensive dissection of a large indirect sac. Division of a large indirect sac is best accomplished by opening the sac on the side opposite the spermatic cord, then completing the division from the inside. The taquer itself is frequently pushed against the tissues and used as a spreader and palpator. However, it must not be forced too deeply into the abdominal wall superolateral to the spermatic cord; doing so might lead to inadvertent entrapment of the sensory nerves. The tacker can be moved from the left to the right port, depending on which position more readily allows placement of the staples perpendicular to the mesh and the abdominal wall.

Once the superior margin is fixed, fixation of the inferior margin is accomplished, beginning at the pubic tubercle and moving laterally along Cooper’s ligament. The mesh is lifted frequently to ensure adequate visualization of the spermatic cord. Care is taken to avoid the adjacent external iliac vessels, which lie inferiorly. Lateral to the cord structures, all tacks are placed superior to the iliopubic tract to prevent subsequent neuralgias involving the lateral cutaneous nerve of the thigh or the branches of the genitofemoral nerve. If the surgeon can palpate the tacker through the abdominal wall with the non-dominant hand, the tacker is above the iliopubic tract. The mesh should lie flat at the end of the procedure.

Step 6: placement of mesh: A 10 x 6 cm sheet of polypropylene mesh is rolled into a tubular shape and introduced into the abdomen through the 10/12 mm umbilical trocar. Prolene is preferable to Marlex in this application because it is less dense, conforms more easily to the posterior inguinal wall, and has larger pores, which facilitate visualization and subsequent securing with staples or tacks. The inherent elasticity and resiliency of Prolene mesh allow it to unroll easily while maintaining its form. The mesh is used to cover the direct space (Hesselbach’s triangle), the indirect space, and the femoral ring areas (i.e., the entire inguinal floor). We do not make a slit in the mesh for the cord.

It is our practice with the TAPP technique to tack the mesh to prevent any migration. We use an endoscopic multifire spiral tacker to secure the mesh, beginning medially and proceeding laterally. The upper margin is first tacked to the rectus abdominis and the transversus abdominis fascia and arch, with care taken to stay 1 to 2 cm above the level of the internal inguinal ring and to avoid the inferior epigastric vessels, up to a point several centimeters lateral to the internal inguinal ring or the indirect hernial defect. Extending mesh fixation to the anterior iliac spine is neither necessary nor desirable. A two-handed technique is recommended for tack placement: one hand is on the tacker, and the other is on the abdominal wall, applying external pressure to place the wall against the tacker. The tacker itself is frequently pushed against the tissues and used as a spreader and palpator. However, it must not be forced too deeply into the abdominal wall superolateral to the spermatic cord; doing so might lead to inadvertent entrapment of the sensory nerves. The tacker can be moved from the left to the right port, depending on which position more readily allows placement of the staples perpendicular to the mesh and the abdominal wall.

Once the superior margin is fixed, fixation of the inferior margin is accomplished, beginning at the pubic tubercle and moving laterally along Cooper’s ligament. The mesh is lifted frequently to ensure adequate visualization of the spermatic cord. Care is taken to avoid the adjacent external iliac vessels, which lie inferiorly. Lateral to the cord structures, all tacks are placed superior to the iliopubic tract to prevent subsequent neuralgias involving the lateral cutaneous nerve of the thigh or the branches of the genitofemoral nerve. If the surgeon can palpate the tacker through the abdominal wall with the non-dominant hand, the tacker is above the iliopubic tract. The mesh should lie flat at the end of the procedure.

Step 7: closure of peritoneum: The peritoneal flap, including the redundant inverted hernial sac, is placed over the mesh, and the peritoneum is reaproximated with the tacker (see Figure 17). Reduction of the intra-abdominal pressure to 8 mm Hg, coupled with external abdominal wall pressure, facilitates a tension-free reapproximation. Alternatively, the peritoneum may be sutured over the mesh, but in most surgeons’ hands, this closure takes longer.

Step 8: closure of fascia and skin: The peritoneal repair is inspected to ensure that there are no major gaps that might result in exposure of the mesh and subsequent formation of adhesions. The trocars are then removed under direct vision, and the pneumoperitoneum is released. The fascia at the 10/12 mm port sites is closed with 2-0 polydioxanone sutures to prevent incisional hernias. The skin is closed with 4-0 absorbable subcuticular sutures.

POSTOPERATIVE CARE

Patients are observed in the recovery room until they are able to ambulate unassisted and to void; if they are unable to void at
the time of discharge, in-and-out catheterization is performed. Patients are advised to resume their usual activities as they see fit; driving a car is permitted when pain is minimal. Outpatient prescriptions for acetaminophen, naproxen, and oxycodone are given, and follow-up visits in the surgical clinic are scheduled for postoperative day 7 to 14. Patients who live alone, have had intraoperative complications, have significant nausea or vomiting, or experience unexplained or inordinate pain are admitted overnight.

DISADVANTAGES AND COMPLICATIONS

Disadvantages

Need for general anesthesia The need for pneumoperitoneum and thus for general anesthesia in laparoscopic herniorrhaphy is sometimes considered a major disadvantage. Nausea, dizziness, and headache are more common in the recovery room after TAPP repair than after Lichtenstein repair. It is not necessarily true, however, that local or regional anesthesia is safer than general anesthesia. Anesthesiology studies critically appraising anesthetic techniques for hernia surgery have shown the choice of general anesthesia over local or regional anesthesia to be safe and, in many cases, advantageous, particularly in patients who are in poor health. Furthermore, TEP repair has been successfully done with patients under epidural and local anesthesia.

Lower cost-effectiveness A study comparing costs at North American teaching hospitals found that TEP repair cost US$852 more than Lichtenstein repair; however, this study could not quantify the cost savings arising from faster recuperation and earlier reentry to the workforce. Some studies have demonstrated economic savings with the use of a laparoscopic approach, in the form of fewer days of work missed and reduced worker’s compensation costs. Operating costs can also be reduced by avoiding the use of disposable instruments. In addition, operating time has been shown to decrease as the surgeon’s experience with the procedure increases.

Complications

Most randomized trials comparing laparoscopic repair with open mesh repair have found the overall complication rate to be comparable between groups. In general, however, the rate of serious perioperative complications, though still low, is increased with the laparoscopic approach.

Complications of access to peritoneal cavity A TAPP repair exposes the patient to several potentially serious risks related to the choice of the transabdominal route. Trocar injuries to the bowel, the bladder, and the vascular structures can occur during the creation of the initial pneumoperitoneum or the subsequent insertion of the trocars. Visceral injury rates reported for the laparoscopic approach, though quite low, are still about 10 times those reported for the open approach. Another complication related to trocar placement is incisional hernia, which can lead to postoperative bowel obstruction; however, this complication can be minimized by using 5 mm trocars and a 5 mm laparoscope instead of the larger 10/12 mm instruments.

Complications of dissection Injuries occurring during dissection are often linked to inexperience with laparoscopic inguinal anatomy. If serious enough, they can necessitate laparotomy. Fortunately, such conversion is rare (< 3%). The most common vascular injuries occurring during laparoscopic inguinal herniorrhaphy are those involving the inferior epigastric vessels and the spermatic vessels. The external iliac, circumflex iliac, profunda, and obturator vessels are also at risk. A previous lower abdominal operation is a risk factor. The source of any abnormal bleeding during the procedure must be quickly identified. All vessels in the groin can be ligated except the external iliac vessels, which must be repaired.

Injuries to the urinary tract may also occur. Four bladder injuries necessitating repair were documented in a collected series of 762 laparoscopic repairs by different surgical groups. Bladder injuries are most likely to occur when the space of Retzius has been previously dissected (e.g., in a prostatectomy). Renal and ureteral injuries identified intraoperatively should be repaired immediately. Often, however, these injuries are not apparent until the postoperative period, when they present as lower abdominal pain, renal failure, ascites, dysuria, or hematuria—all of which should be investigated promptly. Although indwelling catheter drainage may constitute sufficient treatment of a missed retroperitoneal bladder injury, intraperitoneal injuries are best treated by direct repair via either laparoscopy or laparotomy.

Complications related to mesh Complications related to the use of mesh include infection, migration, adhesion formation, and erosion into intraperitoneal organs. Such complications usually become apparent weeks to years after the initial repair, presenting as abscess, fistula, or small bowel obstruction.

Mesh infection is very rare. In the 2003 Cochrane review of antibiotic prophylaxis for nonmesh hernia repairs, the overall infection rate was 4.69% in the control group and 3.08% in the treatment group. Thus, to prevent one infection in 30 days, 50 patients would have to be treated, and these patients would then be at risk for antibiotic-associated complications. Laparoscopic repairs were excluded from this review; however, in a meta-analysis comparing postoperative complications after laparoscopic inguinal hernia repair with those after open repair, superficial infection was less frequent in the laparoscopic groups. Deep mesh infection was rare in both groups. Mesh infection usually responds to conservative treatment with antibiotics and drainage. On rare occasions, the mesh must be removed; this may be accomplished via an external approach. It is noteworthy that removal of the mesh does not always lead to recurrence of the hernia, a finding that may be attributable to the resulting fibrosis.

Mesh migration may lead to hernia recurrence. In a TAPP repair, appropriate stapling of the mesh should reduce this possibility. In a TEP repair, stapling does not appear to be necessary to prevent migration.
The risk that adhesions to the mesh will form is augmented if the mesh is left exposed to the bowel. The long-term durability and effectiveness of the sometimes flimsy peritoneal coverage employed in the TAPP approach have been questioned. Even in the TEP approach, small tears in the peritoneum may expose the bowel to the mesh.

Urinary complications Injuries to the urinary tract aside [see Complications of Dissection, above], urinary retention, urinary tract infection, and hematuria are the most common complications. Avoidance of bladder catheterization reduces the incidence of these complications, but urinary retention still occurs in 1.5% to 3% of patients. General anesthesia and the administration of large volumes of I.V. fluids may also predispose to retention.

Vas deferens and testicular complications Wantz believes that the most common cause of postoperative testicular swelling, orchitis, and ischemic atrophy is surgical trauma to the testicular veins (i.e., venous congestion and subsequent thrombosis). Because spermatic cord dissection is minimized with the laparoscopic approach, the risk of groin and testicular complications resulting from injury to cord structures and adjacent nerves may be reduced. Most testicular complications, such as swelling, pain and epididymitis, are self-limited. Testicular pain occurs in about 1% of patients after laparoscopic repair, an incidence comparable to that seen after open repair. A similar number of patients experience testicular atrophy, for which there is no specific treatment.

The risk of injury to the vas deferens appears to be much the same in laparoscopic repair as in open repair. If fertility is an issue, the cut ends should be reapproximated if the injury is recognized intraoperatively.

Postoperative groin and thigh pain Unlike patients who undergo open anterior herniorrhaphy, in whom discomfort or numbness is usually localized to the operative area, patients who undergo laparoscopic repair occasionally describe unusual but specific symptoms of deep discomfort that are usually positional and are often of a transient, shooting nature suggestive of nerve irritation. The pain is frequently incited by stooping, twisting, or movements causing extension of the hip and can be shock-like. Although these symptoms can frequently be elicited in the early postoperative period, they are usually transient. If tacks or staples were used and neuralgia is present in the recovery room, prompt reexploration is the best approach.

Persistent pain and burning sensations in the inguinal region, the upper medial thigh, or the spermatic cord and scrotal skin region occur when the genitofemoral nerve or the ilioinguinal nerve is stimulated, entrapped, or unintentionally injured. When these symptoms persist, they may result in severe morbidity. A more worrisome symptom is lateral or central upper medial thigh numbness, which is reported in 1% to 2% of patients and often lasts several months or longer. Whether this numbness is related to staple entrapment, fibrous adhesions, cicatrixial neuroma, or mesh irritation is unknown. Numbness and paresthesia of the lateral thigh are less frequent and are related to the involvement of fibers of the lateral cutaneous nerve. These problems can be prevented by paying careful attention to anatomic detail and technique. Anatomic study, based on cadaveric dissections, suggests that both the genitofemoral nerve and the lateral cutaneous nerve of the thigh will be protected in all cases if no staples are placed further than 1.5 cm lateral to the edge of the internal ring.

A great deal of attention has rightly been focused on the risk of nerve injury with laparoscopic hernia repair, as well as on ways of preventing it. At the same time, it is important to note that pain and numbness, including thigh numbness, can also occur after open repair and may in fact be more common in that setting than was previously realized. In one study, persistent groin pain was present in 9.5% of patients after Lichtenstein repair versus 5.5% of patients after TAPP. In the Cochrane meta-analysis, persistent pain and numbness 1 year after surgery were found to be significantly reduced with either TEP or TAPP repair. This finding was confirmed by a 2004 study that reported a 9.8% incidence of neuralgia or other pain at 2 years in patients who underwent laparoscopic repair, compared with a 14.3% incidence in open repair patients.

Miscellaneous complications Laparoscopic repair apparently reduces the incidence of hematoma while increasing that of seromas. Lipomas of the spermatic cord, if left unreduced in patients with indirect hernias, may produce a persistent groin mass and a cough impulse that mimic recurrence, especially to an uninitiated examiner. These lipomas are always asymptomatic.

OUTCOME EVALUATION

Although there is a large body of literature on laparoscopic inguinal hernia repair—including a variety of randomized, controlled trials—the benefits of the laparoscopic approach have not yet been clearly defined or widely accepted. Given the low morbidity and relatively short recovery already associated with the conventional operation, demonstration of any significant differences between the open mesh and laparoscopic techniques requires large study samples. The previously cited meta-analysis done by the Cochrane collaboration addressed this question. Forty-one trials were included in this meta-analysis, ranging in size from 38 to 994 randomized patients. The duration of follow-up ranged from 6 weeks to 36 months. The results of the meta-analysis suggested that whereas operating times were longer and the risk of rare but serious complications higher in the laparoscopic groups, recovery was quicker and persistent pain and numbness less frequent. Recurrence rates did not differ significantly.

In addition, a large randomized, multicenter Veterans Affairs (VA) study published in 2004 compared open mesh repair with laparoscopic mesh repair (TEP, 90%; TAPP, 10%) in 2,164 patients. Patients with previous mesh repairs were excluded. In this study, the laparoscopic approach was associated with a higher risk of complications and, in contrast to the findings of the meta-analysis, a higher overall recurrence rate at 2 years after operation. Pain was reduced and recovery time shortened in the laparoscopic group.

Thus, there remains a degree of controversy regarding the ideal approach to and outcome for inguinal hernia repair. Accordingly, we will briefly review the salient outcomes of a number of studies that compare laparoscopic inguinal herniorrhaphy with open mesh repair.

LAPAROSCOPIC REPAIR VERSUS OPEN MESH REPAIR

Operating time The Cochrane meta-analysis suggested that overall, the average operating time was 15 minutes longer with the laparoscopic approach; however, for bilateral hernias, laparoscopic repair required no more time than open repair. The surgeon’s level of experience with laparoscopic technique was not explicitly stated in all of these studies, which made it difficult to assess the impact of this variable on operating time. It has been shown that with more experience and greater specialization, the differences in operating time between laparoscopic and open repair tend to decrease and become clinically unimportant.
Recovery time  The most significant short-term outcome measure after hernia repair is recovery time, defined as the time required for the patient to return to normal activities. One of the most frequently cited benefits of laparoscopic herniorrhaphy is the patient’s rapid return to unrestricted activity, including work. The Cochrane meta-analysis revealed that recovery time was significantly shorter after laparoscopic repair than after open mesh repair. In a cost comparison between TEP repair and Lichtenstein repair, recovery time was 15 days after the former, compared with 34 days after the latter. In the 2004 VA study, laparoscopic repair patients returned to their normal activities 1 day earlier.

Postoperative pain After laparoscopic repair, most patients experience minimal immediate postoperative pain and have little or no need for analgesics after postoperative day 1. Patients are able to perform some exercises better after laparoscopic repair than after Lichtenstein repair. That patients experience less postoperative pain after laparoscopic repair than after open mesh repair has been reported in several randomized studies. In the Cochrane meta-analysis, persistent pain and numbness 1 year after surgery was significantly less after either TEP or TAPP repair than after open repair. In a 2003 report describing a 5-year follow-up of 400 patients treated with either Lichtenstein open mesh repair or TAPP repair, the incidence of permanent paresthesia and groin pain was lower with the TAPP approach. Moreover, all of the patients with pain and paresthesia significant enough to affect their daily lives were in the open repair group. A later study that evaluated postoperative neuralgia in 400 patients who underwent either TAPP repair or Lichtenstein repair reported similar findings.

Quality of life The studies that have assessed quality of life immediately after hernia repair have tended to favor the laparoscopic approach, albeit marginally. Using the SF-36 (a widely accepted general health-related quality-of-life questionnaire), one group found that at 1 month, greater improvements from baseline were apparent in the laparoscopic group in every dimension except general health; however, by 3 months, the differences between the two groups were no longer significant. Another group also found no differences in any SF-36 domains at 3 months after operation. Yet another study, however, using the Sickness Impact Profile, found some benefit to the laparoscopic approach. In contrast, no postoperative differences in SF-36 domains were found in the VA study.

Bilateral hernias Laparoscopy allows simultaneous exploration of the abdominal cavity (TAPP) and diagnosis and treatment of bilateral groin hernias, as well as coexisting femoral hernias (which are often unrecognized preoperatively), potentially without added risk or disability. Bilateral hernias accounted for 9% of the hernias reviewed in the Cochrane database. Operating time was longer in the laparoscopic groups than in the open groups; however, recovery time, the incidence of persistent numbness, and the risk of wound infection were significantly reduced in the former. These results are consistent with those of a prospective, randomized, controlled trial from 2003 that compared TAPP repair with open mesh repair for bilateral and recurrent hernias. In this study, TAPP repair not only was less painful and led to an earlier return to work but also was associated with a shorter operating time. Further prospective, randomized trials designed to compare simultaneous bilateral open tension-free repair with bilateral TEP laparoscopic repair should be undertaken.

Recurrent hernias Approximately 10% of patients undergoing hernia repair present with recurrent inguinal hernia. Patients with recurrent hernias may potentially derive greater benefits from a laparoscopic approach through an undisturbed plane of dissection, rather than a second groin exploration via an open technique, dissecting through scar tissue and potentially causing significant tissue trauma. This is especially true when mesh was used for the previous open repair.

Open mesh repair has been associated with long-term recurrence rates of 1% or less, even when not performed by hernia specialists. If the laparoscopic approach is to be a viable alternative to open repair, it should have comparable results. With respect to short-term results, prospective, randomized trials suggest that hernia recurrence rates are comparable in laparoscopic repair and open mesh repair groups. However, the Cochrane meta-analysis found that reductions in hernia recurrence were effected primarily by the use of mesh rather than by any specific placement technique. This finding is consistent with the Cochrane meta-analysis of open mesh inguinal hernia repair versus open nonmesh repair, which indicated that tension-free mesh repair led to a significant reduction in hernia recurrence. In a 5-year follow-up study from 2004, the recurrence rate after laparoscopic mesh repair still was not significantly different from that after open mesh repair. In the VA study, the hernia recurrence rate at 2 years was higher in the laparoscopic group (10%) than in the open mesh repair group (4%) for primary, unilateral hernias. In both groups, the recurrence rates were higher than generally expected. However, these rates were found to be affected by the surgeon’s level of experience: those who had performed more than 250 laparoscopic repairs reported a recurrence rate of 5%.

Most reported recurrences after laparoscopic herniorrhaphy come at an early stage in the surgeon’s experience with these procedures and arise soon after operation. The majority can be attributed to (1) inadequate preperitoneal dissection; (2) use of an inadequately sized patch, which may migrate or fail to support the entire inguinal area, including direct, indirect, and femoral spaces; or (3) staple failure with TAPP repair.

Transabdominal Preperitoneal Repair (TAPP) versus Totally Extraperitoneal Repair (TEP)

The TAPP approach is easier to learn and perform than the TEP approach, and even experienced laparoscopic hernia surgeons report more technical difficulties with the latter. Nonetheless, there is a growing body of literature to suggest that TEP repair, by avoiding entry into the peritoneal cavity, has significant advantages over TAPP repair. In particular, the TEP approach should reduce the risk of trocar site hernias, small bowel injury and obstruction, and intraperitoneal adhesions to the mesh. In a study that included 426 patients, TAPP repairs were performed in 339 and TEP repairs in 87, and the patients were followed for a mean of 23 and 7 months, respectively. Time off work was shorter after TEP. A total of 15 major complications were noted, including one death, two bowel obstructions, one severe neuralgia, three trocar site hernias, one epigastric artery hemorrhage, and seven recurrences. With the exception of the epigastric artery hemorrhage, all of these complications occurred in the TAPP group. It is possible, however, that these results can be partly explained by the learning curve, in that the TAPP repairs were all done before the TEP repairs. That six TAPP recurrences occurred in the first 31 cases, whereas only one occurred in the subsequent 395 cases, lends support to this possibility.

In a study comparing 733 TAPP repairs with 382 TEP repairs, 11 major complications occurred in the TAPP group (two recur-
rences, six trocar site hernias, one small bowel obstruction, and two small bowel injuries), whereas only one recurrence and no intraperitoneal complications occurred in the TEP group. Six TEP procedures were converted to TAPP procedures. Time off work was equal in the two groups but was prolonged in patients receiving compensation. As in the study cited above, the TAPP patients were followed longer than the TEP patients, and the TAPP cases occupied the first part of the learning curve. To avoid this type of selection bias would require a randomized study.

Not all surgeons are convinced that TEP repair is the laparoscopic procedure of choice. A 1998 study compared 108 TAPP repairs with 100 TEP repairs. Although the TEP repairs were done only by surgeons who were already familiar with TAPP repair, many of the surgeons still encountered technical difficulties and problems with landmark identification. Overall, complications did not occur significantly more frequently in either group, but they seemed more severe in the TAPP group: four trocar site hernias, one bladder injury, and six seromas were noted in the TAPP group, compared with one cellulitis and six seromas in the TEP group. The authors concluded that because TAPP repair is easier and does not increase complications significantly, it is an “adequate” procedure. The sample size may have been too small to permit detection of small differences in complication rates.

Regardless of any individual preference for one technique or the other, laparoscopic hernia surgeons ideally should be capable of performing both TEP and TAPP well. For example, a planned TEP repair may have to be converted to a TAPP repair, or a TAPP approach may be required if the surgeon is doing another intra-peritoneal diagnostic or therapeutic procedure.

### Laparoscopic Incisional Hernia Repair

Incisional hernias develop in approximately 2% to 11% of patients undergoing laparotomy. It has been estimated that 90,000 ventral hernia repairs are done in the United States every year. When prosthetic mesh is not used, repair of large incisional hernias is associated with recurrence rates as high as 63% after 10 years, compared with 32% when mesh is used. In addition to these high recurrence rates, even with the use of mesh, open incisional hernia repair may be associated with significant complications and a substantial hospital stay.

Initially described in 1992, laparoscopic repair of incisional hernias has evolved from an investigational procedure to one that can safely and successfully be used to repair ventral hernias. Taking a laparoscopic approach allows the surgeon to minimize abdominal wall incisions, avoid extensive flap dissection and muscle mobilization, and eliminate the need for drains in proximity to the mesh, thereby potentially achieving reductions in pain, recovery time, and duration of hospitalization, as well as lower rates of surgical site infection (SSI). In addition, the improved visualization of the abdominal wall associated with the laparoscopic view may result in better definition of the defect, the discovery of unrecognized hernia sites, and improved adhesiolysis. Improved visualization permits more precise and accurate placement and tailoring of the mesh, as is suggested by the reduced recurrence rates (9% to 12%) reported up to 5 years after laparoscopic incisional herniorrhaphy.

### PREOPERATIVE EVALUATION

#### Selection of Patients

Laparoscopic incisional hernia repair may be considered for any ventral hernia in which mesh will be used for the repair. This category includes virtually all incisional hernias, in that even small 0000(< 10 cm²) de0f000ects are known to carry a significant risk of recurrence. Both upper abdominal and lower abdominal incisions are amenable to a laparoscopic approach, although hernias at the extremes of the abdominal wall—abutting the pubis, the xiphoid, or the costal margins—pose a technical challenge for effective mesh fixation. The so-called Swiss cheese hernia, which comprises multiple small defects, is particularly well suited to this approach; open repair would necessitate a large incision for access to the multiple fascial defects, and small defects might not be appreciated. Incarcerated hernias can also be approached laparoscopically; however, the suspected presence of compromised bowel is a contraindication. An abdomen that has undergone multiple operations and contains dense adhesions presents a challenge in terms of both access to the abdominal cavity and access to the hernia site. If the surgeon cannot obtain safe access to the peritoneal cavity for insufflation, a laparoscopic approach is contraindicated.

#### Contraindications

Laparoscopic incisional herniorrhaphy is contraindicated in patients with suspected strangulated bowel or loss of domain. Hernias in which the fascial edges extend lateral to

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**Table 1** Meshes Used for Incisional Hernia Repair

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Product Name</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gore</td>
<td>Dualmesh</td>
<td>Dual-sided ePTFE</td>
</tr>
<tr>
<td></td>
<td>Dualmesh Plus</td>
<td>Dual-sided ePTFE, antibiotic-impregnated</td>
</tr>
<tr>
<td>Bard/Davol</td>
<td>Composix</td>
<td>Polypropylene/ePTFE laminate</td>
</tr>
<tr>
<td></td>
<td>Composix E/X</td>
<td>Polypropylene/ePTFE laminate</td>
</tr>
<tr>
<td></td>
<td>Composix Kugel</td>
<td>Polypropylene/ePTFE laminate</td>
</tr>
<tr>
<td></td>
<td>Vialix</td>
<td>Polypropylene/ePTFE laminate</td>
</tr>
<tr>
<td></td>
<td>Dulex</td>
<td>Dual-sided ePTFE</td>
</tr>
<tr>
<td></td>
<td>Reconix</td>
<td>Dual-sided ePTFE</td>
</tr>
<tr>
<td>Genzyme</td>
<td>Sepramesh</td>
<td>Polypropylene/HA/CMC laminate</td>
</tr>
<tr>
<td>Sofradim</td>
<td>Parietex</td>
<td>Polyester/type I collagen hydrophilic film laminate</td>
</tr>
<tr>
<td>Brennan Medical</td>
<td>Glucamesh</td>
<td>Polypropylene/p-glucan laminate</td>
</tr>
<tr>
<td></td>
<td>Glucatex</td>
<td>Polypropylene/p-glucan laminate</td>
</tr>
<tr>
<td>Ethicon Endo-Surgery</td>
<td>Proceed</td>
<td>Polypropylene/oxidized regenerated cellulose</td>
</tr>
<tr>
<td>Cook</td>
<td>Surgis Surgis</td>
<td>Porcine intestinal submucosa</td>
</tr>
</tbody>
</table>
|                | Gold         | ePTFE—expanded polytetrafluoroethylene /
|                |              | HA/CMC—hyaluronate/carboxymethylcellulose        |

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**Table 2** Devices Used for Mesh Fixation in Incisional Hernia Repair

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Device Name</th>
<th>Fixation Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Surgical</td>
<td>TACKER</td>
<td>Steel spiral tacks</td>
</tr>
<tr>
<td>Ethicon Endo-Surgery</td>
<td>EndoANCHOR</td>
<td>Nitinol anchors</td>
</tr>
<tr>
<td>Sofradim</td>
<td>Parifex</td>
<td>Polyglycolic T-fasteners</td>
</tr>
<tr>
<td>Onux Medical</td>
<td>Salute</td>
<td>Wire loop deployment</td>
</tr>
</tbody>
</table>
the midclavicular line may make trocar placement lateral to the defect impossible. Defects in close proximity to the bony margins of the abdomen, especially those near the xiphoid, pose significant challenges for mesh fixation, though this is also true with open incisional herniorrhaphy. Patients who have undergone multiple previous operations, with or without mesh, may have dense adhesions. Patients in whom polypropylene mesh has previously been placed in an intra-abdominal position may have dense adhesions to the underlying viscera. Whether such patients are approached laparoscopically should be determined by the surgeon’s expertise.

OPERATIVE PLANNING

Preparation

The procedure is performed with the patient under general anesthesia. Mechanical bowel preparation is not routinely used; however, it may be considered if incarcerated colon is suspected. If the defect is in the lower abdomen, a three-way Foley catheter is placed in the bladder. Sequential compression stockings are applied. Patients are routinely given heparin, 5,000 U subcutaneously, and prophylactic antibiotics.67

Positioning

The patient is placed in the supine position with both arms tucked. If the hernia is in the midline, the surgeon can stand on either side of the patient, with the monitor directly opposite. If the hernia extends significantly to one side, initial trocar placement is done on the opposite side. Initially, the assistant stands on the same side as the surgeon; however, he or she may later have to move to the opposite side to help with dissection and stapling. A second monitor on the opposite side of the table is useful. If the defect is subcostal, the surgeon may prefer to operate from between the patient’s legs, with a monitor at the head of the bed.

Equipment

As the wide variety of mesh materials currently available suggests, there is no one ideal mesh. Meshes may be divided into two categories: (1) polymeric meshes and (2) meshes made of specially prepared connective tissue (animal or human) [see Table 1]. The polymeric meshes are biocompatible materials made of either polypropylene, polyester, expanded polytetrafluoroethylene (ePTFE), or laminates of these. Most ePTFE meshes are engineered so that one side is porous to encourage tissue ingrowth and the other is smooth to resist adhesion formation. They may also be coated with an adhesion-resisting absorbable material.

Because laparoscopic incisional hernia repair leaves the mesh exposed to the intraperitoneal cavity, concerns have been expressed about the risk of adhesion formation and fistulization if polypropylene mesh is used. Polytetrafluoroethylene (PTFE) mesh has been demonstrated to have a reduced propensity for adhesion formation. Additional special equipment used for incisional hernia repair includes a suture passer, a 5 mm spiral tacker (or other tacking device), and 2-0 monofilament sutures. Several tacking devices and suture placement devices have been developed to facilitate mesh fixation [see Table 2]. All work in essentially the same manner. A Keith or similar needle may also be used. Atraumatic bowel instruments are required to manipulate the bowel if lysis of adhesions is needed.

OPERATIVE TECHNIQUE

In essence, the repair consists of the intraperitoneal placement of a large piece of mesh so that it overlaps the defect in the fascia and the abdominal wall. The defect is not closed. The mesh is anchored with a minimum of four subcutaneously tied transfascial sutures placed at the four corners and is further secured between the sutures with intraperitoneally placed tacks and additional sutures as needed.

Step 1: placement of trocars

Because of the probability of extensive intra-abdominal adhesions, we begin with open insertion of a blunt 12 mm trocar. Although open insertion necessitates an often tedious dissection through several layers of the abdominal wall, it has the advantage of allowing early diagnosis and repair of any iatrogenic bowel injury. Nevertheless, good results have also been reported with insertion of a Veress needle, usually in the left upper quadrant (where adhesions are presumed to be minimal). Ultimately, trocar position is determined by the location of the hernia. For midline hernias, we usually begin on the left side of the patient and insert the first trocar lateral to the edges of the defect, about midway between the costal margin and the iliac crest.

CO2 is then insufflated to a pressure of 12 to 15 mm Hg, and a 5 mm 30° scope is inserted. As in laparoscopic inguinal hernia repair, an angled scope is essential because dissection and repair are done on the undersurface of the anterior abdominal wall, which cannot be adequately visualized with a 0° scope. The hernial defect is visually identified, and two additional 5 mm trocars are placed on the same side under direct vision, with their precise placement dependent on the size and contours of the defect and on the locations of any adhesions. If possible, these trocars are placed superior and inferior to the initial trocar, as far laterally as possible, with care taken to ensure that the downward movement of the instruments is not limited by the iliac crest or the thigh. Lateral placement is necessary to optimize exposure of the abdominal wall [see Figure 18].

Step 2: exposure of hernial defect

The edges of the hernial defect are exposed by reducing the contents of the hernia into the abdominal cavity. All adhesions from bowel or omentum to the abdominal wall in the vicinity of the defect and along the full length of the previous incision should be divided. Complete adhesiolysis of abdominal wall adhesions facilitates the identification of
Swiss cheese defects [see Figure 19]. Starting in the upper abdomen may be easier, in that bowel adhesions are less likely to be encountered. External pressure may also help reduce hernial contents and facilitate identification of the hernial sac. Placing the patient head down or head up and rotating the table will also aid in exposure. If dense adhesions are present, it is preferable to divide the sac or the fascia, so as not to risk bowel injury [see Figure 20]. Sharp dissection with scissors is recommended to prevent thermal injury to the bowel, which may not be immediately recognized. If incarcerated bowel cannot be reduced with laparoscopic techniques, an incision is made over the area of concern, and the bowel is freed under direct vision. Once this incision is closed, laparoscopic mesh placement can proceed, and there may be no need for full conversion to an open operation. Strategies for avoidance and treatment of bowel injury are discussed in more detail elsewhere [see Complications, Bowel Injury, below].

**Step 3: selection of mesh** The contours of the hernial defect are marked as accurately as possible on the exterior abdominal wall; the edges may be delineated with a combination of palpation and visualization. All Swiss cheese defects are marked. The defect is measured after pneumoperitoneum is released to ensure that its size is not overestimated [see Figure 21]. Ideally, the prosthesis should overlap the defect by at least 3 cm on all sides. Coverage of all of the defects with a single sheet of mesh is preferred, but more than one sheet may be needed, depending on the locations of the defects and the size of the patient. The mesh sheet is laid on the abdominal wall in a position that approximates its eventual intra-abdominal position, and its four corners and those of its representation on the abdominal wall are numbered clockwise from 1 through 4 for later orientation [see Figure 22]. A mark is made on the inner side of the mesh sheet so that the surgeon can easily determine which side is to face the peritoneum once the mesh is inserted into the peritoneal cavity. If a dual-sided mesh is being used, the smooth side must be the one facing the bowel. A 2-0 monofilament suture is tied in each corner of the mesh, and both ends of each suture are left about 15 cm long.

The mesh swatch is rolled as tightly as possible around a grasping forceps and introduced into the peritoneal cavity. Small swatches can be inserted through a 12 mm trocar; for larger pieces, we remove a large trocar and insert the mesh directly into the abdomen. The trocar is then repositioned and insufflation of CO₂ recommenced.

**Step 4: fixation of mesh** Once the mesh swatch has been introduced into the abdomen, it is unfurled and spread out, with the previously placed corner sutures facing the fascia and oriented so that the four numbered corners are aligned with the numbers marked on the abdominal wall. Small skin incisions are then made with a No. 11 blade. Through each of these incisions, a suture passer is inserted to grasp one tail of the previously placed anchoring suture and pull it out through the abdominal wall. This is done for each of the four anchoring sutures. Once the mesh swatch has been introduced, it is unfurled and spread out, with the previously placed corner sutures facing the fascia and oriented so that the four numbered corners are aligned with the numbers marked on the abdominal wall. Small skin incisions are then made with a No. 11 blade. Through each of these incisions, a suture passer is inserted to grasp one tail of the previously placed anchoring suture and pull it out through the abdominal wall, then reintroduced through the incision at a slightly different angle to pull out the second tail. This is done for each of the four anchoring sutures, and the mesh is unfurled under appropriate tension (with care taken to avoid excessive tension and stretching). Initially, the corner sutures are held with hemostats and not tied; some adjustment to achieve optimal positioning of the mesh is often required, especially early in the surgeon’s experience.

Once the mesh is in a satisfactory position, each suture is tied and buried in the subcutaneous tissue to anchor the mesh swatch to the fascia and maintain its proper orientation [see Figure 23]. With large defects, it is usually necessary to place one or more additional 5 mm trocars contralateral to the initial ports to aid in mesh fixation. A tacker is then employed to tack the mesh circumferentially at 1 cm intervals along its edge. A two-handed technique is used, in which the second hand applies external pressure to the abdominal wall to ensure that the tacks obtain the best possible purchase on the mesh and the abdominal wall [see Figure 24]. Care should be taken to place the tacks flush because they can cause bowel injury if left protruding. Additional sutures are then passed at 5 cm intervals directly through the mesh with either the suture passer and a free suture or a suture on a Keith needle. Sutures should be tied taut but not tight, so as not to cause necrosis of the intervening tissue.

**Step 5: closure** The pneumoperitoneum is released. The fascia at any trocar site 10 mm in diameter or larger is closed. Careful closure of the site used for open insertion of the first trocar is mandatory to prevent trocar site hernia. The skin is then closed with subcuticular sutures.

**POSTOPERATIVE CARE**

The Foley catheter is removed at the end of the procedure. Unless adhesiolysis was minimal, patients are admitted to the hos-
hospital. Oral intake is begun immediately. Patients are discharged when oral intake is tolerated and pain is controlled with oral medication. Patients are informed that fluid will accumulate at the hernia site and are asked to report any fever or redness. Finally, patients are instructed to resume all regular activities as soon as they feel capable.

SPECIAL SITUATIONS

Suprapubic Hernia

For hernial defects that extend to the pubic bone, a three-way Foley catheter is inserted. After adhesiolysis, the patient is placed in the Trendelenburg position, and the bladder is distended with methylene blue in saline. The bladder is dissected off the pubic bone until Cooper’s ligament is reached. The mesh is then placed so that it extends behind the bladder and is tacked to the pubic bone, to Cooper’s ligament, or to both.

Subxiphoid or Subcostal Hernia

A hernia in which there is no fascia between the hernia and the ribs or the xiphoid (e.g., a poststernotomy hernia) poses significant challenges for fixation. Because of the risk of intrathoracic injury, the mesh is not tacked to the diaphragm. Although some surgeons perform mesh fixation to the ribs, this measure is often associated with significant postoperative pain and morbidity. In these situations, we take down the falciform ligament and lay the mesh along the diaphragm above the liver, placing tacks and sutures up to but not above the level of the costal margin. Taking down the falciform ligament may be a helpful step for all upper abdominal wall hernia repairs. The recurrence rates for subxiphoid and subcostal hernias are higher than those for hernias at other locations.

Parastomal Hernias

As many as 50% of stomas are complicated by parastomal hernia formation, and 10% to 15% will require operative intervention for obstruction, pain, difficulty with stoma care, or unsatisfactory cosmesis. Three methods of repair have been described:
primary fascial repair, repair with mesh, and stoma relocation [see 5:27 Open Hernia Repair]. Repair via a laparoscopic approach that uses ePTFE mesh has shown promising short-term results.72,73 The technique that currently seems to be the most successful is the one described by LeBlanc and Bellanger.73 Rather than lateralizing the intestine (as in the technique described by Sugarbaker74), this method centralizes the intestine in the mesh by cutting an appropriately sized hole in the middle of the mesh sheet, along with a slit to allow it to be placed around the intestine. This step is repeated on a second piece of mesh, but with the slit oriented to the opposite side. The mesh is fixed with sutures and tacks in such a way that it overlaps the defect by at least 3 cm (more commonly, 5 cm) on all sides, as in other ventral hernia repairs. This method appears to minimize the risk of mesh prolapse and bowel herniation alongside the stoma. The authors reported no recurrences within their 3- to 11-month follow-up period and no morbidity. In contrast, a subsequent study reported recurrences within 12 months in five of nine patients who underwent a variation of this repair, in which a slit in the mesh (instead of a central defect) was created and only one mesh sheet (instead of two) was used to cover the defect.71

Laparoscopic parastomal hernia repair appears to be a viable alternative to laparotomy or stoma relocation, but long-term multicenter evaluation is necessary for full assessment of this technique's value in this setting.

COMPLICATIONS

Overall, fewer complications are reported after laparoscopic incisional herniorrhaphy than after open mesh repair.8,63,75-77 There are, however, several specific complications that are of particular relevance in laparoscopic procedures (see below).

Bowel Injury

A missed bowel injury is a potentially lethal complication. The overall incidence of bowel injury does not differ significantly between open repair and laparoscopic repair and is generally low with either approach (1% to 5% when serosal injuries are included). It should be noted, however, that pneumoperitoneum may hinder the recognition of bowel injury at the time of operation. There have also been several reports of late bowel perforation secondary to thermal injury with laparoscopic repair;65,76-79 One study reported two bowel injuries that were not discovered until 12 months in five of nine patients who underwent a variation of this repair, in which a slit in the mesh (instead of a central defect) was created and only one mesh sheet (instead of two) was used to cover the defect.71

Seroma formation is one of the most commonly reported complications: it occurs immediately after operation in virtually all patients, to some extent.65,80,85 Patients sometimes mistake a tense seroma for recurring incisional hernia, but appropriate preoperative discussion should provide them with significant reassurance on this point. Seroma formation seems not to be related to particular mesh types or to the use of drains.80 Virtually all seromas resolve spontaneously over a period of weeks to months, with fewer than 5% persisting for more than 8 weeks.64 They are rarely clinically significant. Aspiration may increase the risk of mesh infection.84

Infection

Overall wound complication rates have been shown to be lower with laparoscopic incisional herniorrhaphy than with open repair.65,79,80,85 In particular, SSIs appear to be reduced with the laparoscopic approach.55,79,80,85 SSI rates for open incisional repair range from 5% to 20%,63,79,80,85 whereas those for laparoscopic repair range from 1% to 8%.65,72,79 Mesh infection extensive enough to necessitate mesh removal is rare (incidence ~ 1%); however, SSI after laparoscopic repair, especially when PTFE is used, more frequently results in seeding of the mesh.65,80 Because this type of mesh does not become well incorporated, antibiotic treatment alone is ineffective.80

OUTCOME EVALUATION

Several studies have demonstrated improvements in outcome measures—such as decreased postoperative pain, shorter length of stay, earlier return to work,86 and reduced blood loss—with the laparoscopic approach to incisional hernia repair.5,8,63,64,76,84,87-89

The mean operating time was significantly shorter in the laparoscopic group (87 minutes versus 115.5 minutes), as was the postop-
The recurrence rate—the primary long-term outcome measure of interest—is reported to be reduced after laparoscopic repair. In studies comparing laparoscopic and open incisional hernia repair with mesh, the recurrence rates after the laparoscopic repairs ranged from 0% to 11%, whereas those after the open repairs ranged from 5% to 35%, 5, 6, 7, 8, 8, 8. In expert hands, recurrence rates are low after laparoscopic repair. For example, in a multicenter series of 850 laparoscopic incisional hernia repairs, mostly followed prospectively, the recurrence rate after a mean follow-up period of 20 months was 4.7%. 77. One group found no recurrences in the laparoscopic group and two in the open group after a minimum follow-up period of 18 months. 76 Another group, however, reported a recurrence rate of 18%, 90 which approached that reported after open mesh repair. Recurrence has been associated with lack of suture fixation, prostheses that overlap the defect by less than 2 to 3 cm, postoperative complications, and previous repairs. 6, 6, 5, 7, 7

The surgeon’s level of experience plays a significant role in patient outcome, as demonstrated by a group that compared the outcomes for their first 100 laparoscopic incisional hernia repair patients with those for their second 100. 84 Recurrence rates after a mean follow-up period of 36 months dropped from 9% in the first 100 patients to 4% in the second 100. In addition, the second set of patients were an average of 9 years older, had a higher percentage of recurrent hernias, and exhibited more comorbidities, yet despite these added challenges, operating time was not lengthened, length of stay was similarly short, and the complication rate was no different. Another group reported similar findings for their laparoscopic incisional hernia repair learning curve. 92 Operating times and complication rates in the first 32 patients were comparable to those in the second 32; however, bowel injuries were more common in the first 32.

Although the results of large randomized trials are not available yet, the evidence to date suggests that the laparoscopic approach to the repair of large incisional hernias is highly promising. The laparoscopic approach seems to be safe and compares favorably with the open operation in terms of complication and recurrence rates.
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