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## Gastrointestinal Tract and Abdomen

# Open Hernia Repair: Introduction

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Herniorrhaphy is one of the most commonly performed operations in all of surgery. Worldwide, some 20 million groin hernia repairs are accomplished each year.<sup>1</sup> In the United States, over 1,000,000 herniorrhaphies are performed each year, of which 750,000 are for inguinal hernias, 166,000 for umbilical hernias, 97,000 for incisional hernias, 25,000 for femoral hernias, and 76,000 for miscellaneous hernias.<sup>2</sup> The significance of these large numbers is that small variations in practice patterns can have huge socioeconomic implications. Operations that might seem unimportant because they account for only a small percentage of herniorrhaphies actually are important in that they account for a large absolute number of procedures. Accordingly, though this chapter is necessarily selective, focusing on the most pertinent of the abdominal wall and groin herniorrhaphies being performed today, it addresses a wide variety of operative approaches to hernia repair.

### Epidemiology of Hernia

Approximately 75% of all abdominal wall hernias occur in the groin. Inguinal hernias are more common on the right than on the left and are seven times more likely in males than in females. Indirect inguinal hernias are twice as common as direct hernias. Femoral hernias are much less common than either, accounting for fewer than 10% of all groin hernias; however, 40% of femoral hernias present as emergencies, with incarceration or strangulation, and mortality is higher for emergency repair than for elective repair. Femoral hernias are more common in older patients and in those who have previously undergone inguinal hernia repair. Females are at higher risk than males, by a factor of 4 to 1.<sup>3</sup>

The prevalence of abdominal wall hernias is difficult to determine, as illustrated by the wide range of published figures in the literature. The major reasons for this difficulty are (1) the lack of standardization in how inguinal and ventral hernias are defined, (2) the inconsistency of the data sources used (which include self-reporting by patients, audits of routine physical examinations, and insurance company databases, among others), and (3) the subjectivity of physical examination, even when done by trained surgeons. Prevalence was reported in a United States Health, Education and Welfare study conducted by interview in 1960 for hernia [see *Figure 1 -- omitted*].<sup>4</sup> Given that a number of persons must have had hernias without knowing it, it can be assumed that these figures underestimate the actual prevalence. Nevertheless, they provide a rough idea of the scope of the hernia problem.

Modern data concerning the risk of major complications from untreated abdominal wall hernias are scarce. Typically, surgeons are taught that all hernias, even if asymptomatic, should be repaired at diagnosis to prevent strangulation or bowel obstruction and that herniorrhaphy becomes more difficult the longer repair is delayed. As a result, it is hard to find a whole patient population in which at least some of the members do not undergo routine hernia repair regardless of symptoms. This state of affairs makes accurate estimates of the natural history of hernia impossible.

Examination of obscure data from the 1800s and some unique data from South America suggests that both the risk of complications from an untreated hernia and the operative mortality from managing them have been overstated.<sup>5</sup> At the same time, it is becoming clear that abdominal wall herniorrhaphy is associated with a higher morbidity than was previously appreciated. Currently, numerous patients either choose or are counseled by their primary care physicians not to undergo herniorrhaphy if the hernia is not "bothering them too much." A better understanding of the natural

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history therefore becomes particularly important for identifying patient subgroups who might be at greater risk for complications.

### Classification of Hernia Types

Numerous classification schemes for groin hernias have been devised, usually bearing the name of the responsible investigator or investigators (e.g., Casten, Lichtenstein, Gilbert, Robbins and Rutkow, Bendavid, Nyhus, and Schumpelick). The variety of classifications in current use indicates that the perfect system has yet to be developed.<sup>6</sup> The main problem in developing a single classification scheme suitable for wide application is that it is impossible to eliminate subjective measurements and thus impossible to ensure consistency from observer to observer. The advent of laparoscopic herniorrhaphy has further complicated the issue in that some of the measurements needed cannot be obtained via a laparoscopic approach. At present, the Nyhus system enjoys the greatest degree of acceptance [see *Table 1 -- omitted*].

Categorization of ventral abdominal wall hernias is not as critical as categorization of inguinal hernias, because there are so many different types of ventral hernias; however, Zollinger has proposed a classification scheme for these hernias that is frequently used [see *Table 2 -- omitted*]. Of the ventral hernias, incisional hernias are common enough to warrant their own discrete classification system. The scheme most often used for categorizing incisional hernias [see *Table 3 -- omitted*] represents the results of a 1998 consensus conference held in conjunction with the European Hernia Society's annual congress.<sup>7</sup> This system is important in that it affords investigators a reliable means of comparing results between one procedure and another or between one center and another.

### Abdominal Wall Anatomy

The skin of the lower anterior abdominal wall is innervated by anterior and lateral cutaneous branches of the ventral rami of the seventh through 12th intercostal nerves and by the ventral rami of the first and second lumbar nerves. These nerves course between the lateral flat muscles of the abdominal wall and enter the skin through the subcutaneous tissue.

The first layers encountered beneath the skin are Camper's and Scarpa's fasciae in the subcutaneous tissue. The only significance of these layers is that when sufficiently developed, they can be reapproximated to provide another layer between a repaired inguinal floor and the outside. The major blood vessels of this superficial fatty layer are the superficial inferior and superior epigastric vessels, the intercostal vessels, and the superficial circumflex iliac vessels (which are branches of the femoral vessels).

The external oblique muscle is the most superficial of the great flat muscles of the abdominal wall [see *Figure 2 -- omitted*]. This muscle arises from the posterior aspects of the lower eight ribs and interdigitates with both the serratus anterior and the latissimus dorsi at its origin. The posterior portion of the external oblique muscle is oriented vertically and inserts on the crest of the ilium. The anterior portion of the muscle courses inferiorly and obliquely toward the midline and the pubis. The muscle fibers themselves are of no interest to the inguinal hernia surgeon until they give way to form its aponeurosis, which occurs well above the inguinal region. The obliquely arranged anterior fibers of the aponeurosis of the external oblique muscle fold back on themselves to form the inguinal ligament, which attaches laterally to the anterior superior iliac spine. In most persons, the medial insertion of the inguinal ligament is dual: one portion of the ligament inserts on the pubic tubercle and the pubic bone, whereas the other portion is fan-shaped and spans the distance between the inguinal ligament proper and the pectineal line of the pubis. This fan-shaped portion of the inguinal ligament is called the lacunar ligament. It blends laterally with Cooper's ligament (or, to be anatomically correct, the pectineal ligament). The more medial fibers of the aponeurosis of the external oblique muscle divide into a medial crus and a lateral crus to form the external or superficial inguinal ring, through which the spermatic cord (or the round ligament) and branches of the ilioinguinal and genitofemoral nerves pass. The rest of the medial fibers insert into the linea alba after contributing to the anterior portion of the rectus sheath.

Beneath the external oblique muscle is the internal abdominal oblique muscle. The fibers of the internal abdominal oblique muscle fan out following the shape of the iliac crest, so that the superior fibers course obliquely upward toward the distal ends of the lower three or four ribs while the lower fibers orient themselves inferomedially toward the pubis to run parallel to the external oblique aponeurotic fibers. These fibers arch over the round ligament or the spermatic cord, forming the superficial part of the internal (deep) inguinal ring.

Beneath the internal oblique muscle is the transversus abdominis. This muscle arises from the inguinal ligament, the inner side of the iliac crest, the endoabdominal fascia, and the lower six costal cartilages and ribs, where it interdigitates with the lateral diaphragmatic fibers. The medial aponeurotic fibers of the transversus abdominis contribute to the rectus sheath and insert on the pecten ossis pubis and the crest of the pubis, forming the falx inguinalis. Infrequently, these fibers are joined by a portion of the internal oblique aponeurosis; only when this occurs is a true conjoined tendon formed.<sup>8</sup>

Aponeurotic fibers of the transversus abdominis also form the structure known as the aponeurotic arch. It is theorized that contraction of the transversus abdominis causes the arch to move

downward toward the inguinal ligament, thereby constituting a form of shutter mechanism that reinforces the weakest area of the groin when intra-abdominal pressure is raised. The area beneath the arch varies. Many authorities believe that a high arch, resulting in a larger area from which the transversus abdominis is by definition absent, is a predisposing factor for a direct inguinal hernia. The transverse aponeurotic arch is also important because the term is used by many authors to describe the medial structure that is sewn to the inguinal ligament in many of the older inguinal hernia repairs.

The rectus abdominis forms the central anchoring muscle mass of the anterior abdomen. It arises from the fifth through seventh costal cartilages and inserts on the pubic symphysis and the pubic crest. It is innervated by the seventh through 12th intercostal nerves, which laterally pierce the aponeurotic sheath of the muscle. The semilunar line is the slight depression in the aponeurotic fibers coursing toward the muscle. In a minority of persons, the small pyramidalis muscle accompanies the rectus abdominis at its insertion. This muscle arises from the pubic symphysis. It lies within the rectus sheath and tapers to attach to the linea alba, which represents the conjunction of the two rectus sheaths and is the major site of insertion for three aponeuroses from all three lateral muscle layers. The line of Douglas (i.e., the arcuate line of the rectus sheath) is formed at a variable distance between the umbilicus and the inguinal space because the fasciae of the large flat muscles of the abdominal wall contribute their aponeuroses to the anterior surface of the muscle, leaving only transversalis (or transverse) fascia to cover the posterior surface of the rectus abdominis.

The innervation of the anterior wall muscles is multifaceted. The seventh through 12th intercostal nerves and the first and second lumbar nerves provide most of the innervation of the lateral muscles, as well as of the rectus abdominis and the overlying skin. The nerves pass anteriorly in a plane between the internal oblique muscle and the transversus abdominis, eventually piercing the lateral aspect of the rectus sheath to innervate the muscle therein. The external oblique muscle receives branches of the intercostal nerves, which penetrate the internal oblique muscle to reach it. The anterior ends of the nerves form part of the cutaneous innervation of the abdominal wall. The first lumbar nerve divides into the ilioinguinal nerve and the iliohypogastric nerve [see *Figure 3 -- omitted*]. These important nerves lie in the space between the internal oblique muscle and the external oblique aponeurosis. They may divide within the psoas major or between the internal oblique muscle and the transversus abdominis. The ilioinguinal nerve may communicate with the iliohypogastric nerve before innervating the internal oblique muscle. The ilioinguinal nerve then passes through the external inguinal ring to run parallel to the spermatic cord, while the iliohypogastric nerve pierces the external oblique muscle to innervate the skin above the pubis. The cremaster muscle fibers, which are derived from the internal oblique muscle, are innervated by the genitofemoral nerve. There can be considerable variability and overlap.

The blood supply of the lateral muscles of the anterior wall comes primarily from the lower three or four intercostal arteries, the deep circumflex iliac artery, and the lumbar arteries. The rectus abdominis has a complicated blood supply that derives from the superior epigastric artery (a terminal branch of the internal thoracic [internal mammary] artery), the inferior epigastric artery (a branch of the external iliac artery), and the lower intercostal arteries. The lower intercostal arteries enter the sides of the muscle after traveling between the oblique muscles; the superior and the inferior epigastric arteries enter the rectus sheath and anastomose near the umbilicus.

The endoabdominal fascia is the deep fascia covering the internal surface of the transversus abdominis, the iliacus, the psoas major and minor, the obturator internus, and portions of the periosteum. It is a continuous sheet that extends throughout the extraperitoneal space and is sometimes referred to as the wallpaper of the abdominal cavity. Commonly, the endoabdominal fascia is subclassified according to the muscle being covered (e.g., iliac fascia or obturator fascia).

The transversalis fascia is particularly important for inguinal hernia repair because it forms anatomic landmarks known as analogues or derivatives. The most significant of these analogues for hernia surgeons are the iliopectineal arch, the iliopubic tract, the crura of the deep inguinal ring, and Cooper's ligament (i.e., the pectineal ligament). The superior and inferior crura form a "monk's hood"—shaped sling around the deep inguinal ring. This sling has functional significance, in that as the crura of the ring are pulled upward and laterally by the contraction of the transversus abdominis, a valvular action is generated that helps preclude indirect hernia formation. The iliopubic tract is the thickened band of the transversalis fascia that courses parallel to the more superficially located inguinal ligament. It is attached to the iliac crest laterally and inserts on the pubic tubercle medially. The insertion curves inferolaterally for 1 to 2 cm along the pectineal line of the pubis to blend with Cooper's ligament, ending at about the midportion of the superior pubic ramus. Cooper's ligament is actually a condensation of the periosteum and is not a true analogue of the transversalis fascia.

Hesselbach's inguinal triangle is the site of direct inguinal hernias. As viewed from the anterior aspect, the inguinal ligament forms the base of the triangle, the edge of the rectus abdominis forms the medial border, and the inferior epigastric vessels form the superolateral border. (It should be noted, however, that Hesselbach actually described Cooper's ligament as the base.)

Below the iliopubic tract are the critical anatomic elements from which a femoral hernia may develop. The iliopectineal arch separates the vascular compartment that contains the femoral vessels from the neuromuscular compartment that contains the iliopsoas muscle, the femoral nerve, and the lateral femoral cutaneous nerve. The vascular compartment is invested by the femoral sheath, which has three subcompartments: (1) the lateral, containing the femoral artery

and the femoral branch of the genitofemoral nerve; (2) the middle, containing the femoral vein; and (3) the medial, which is the cone-shaped cul-de-sac known as the femoral canal. The femoral canal is normally a 1 to 2 cm blind pouch that begins at the femoral ring and extends to the level of the fossa ovalis. The femoral ring is bordered by the superior pubic ramus inferiorly, the femoral vein laterally, and the iliopubic tract (with its curved insertion onto the pubic ramus) anteriorly and medially. The femoral canal normally contains preperitoneal fat, connective tissue, and lymph nodes (including Cloquet's node at the femoral ring), which collectively make up the femoral pad. This pad acts as a cushion for the femoral vein, allowing expansion such as might occur during a Valsalva maneuver, and serves as a plug to prevent abdominal contents from entering the thigh. A femoral hernia exists when the blind end of the femoral canal becomes an opening (the femoral orifice) through which a peritoneal sac can protrude.

Between the transversalis fascia and the peritoneum is the preperitoneal space. In the midline behind the pubis, this space is known as the space of Retzius; laterally, it is referred to as the space of Bogros. The preperitoneal space is of particular importance for surgeons because many of the inguinal hernia repairs (see below) are performed in this area. The inferior epigastric vessels, the deep inferior epigastric vein, the iliopubic vein, the rectus abdominis vein, the retropubic vein, the communicating rectus abdominis epigastric vein, the internal spermatic vessels, and the vas deferens are all encountered in this space.<sup>9</sup>

### **Inguinal Herniorrhaphy: Choice of Procedure**

The major indication for a surgeon to choose any one inguinal hernia repair over another is personal experience with a particular operation. Thus, in theory, any patient can be considered a candidate for any of these procedures. Some general guidelines are useful, however. The overriding consideration should be the need to tailor the operation to the patient's particular hernia. For example, a simple Marcy repair would be completely adequate for a pediatric patient with a Nyhus type 1 hernia but not for an elderly patient who has an indirect hernia in conjunction with extensive destruction of the inguinal floor. The conventional anterior prosthetic repairs are particularly useful in high-risk patients because they can easily be performed with local anesthesia. On the other hand, giant prosthetic reinforcement of the visceral sac (GPRVS), especially when bilateral, necessitates general or regional anesthesia and thus is best for patients with bilateral direct or recurrent hernias or, perhaps, for patients with connective tissue disorders that appear to be associated with their hernia. If surgery has previously been done in either the anterior or the preperitoneal space, the surgeon should choose a procedure that uses the undissected space. If local or systemic infection is present, a nonprosthetic repair is usually considered preferable, though the newer biologic prosthesis now being evaluated may eventually change this view. Uncorrected coagulopathy is a contraindication to elective repair.

### **Inguinal Herniorrhaphy: Conventional Anterior Nonprosthetic Repairs**

#### **Anesthesia**

Local anesthesia is entirely adequate, especially when combined with I.V. infusion of a rapid-acting, short-lasting, amnesic, and anxiolytic agent such as propofol. This is the approach most commonly employed in specialty hernia clinics. In general practice, general anesthesia is preferred. This approach is reasonable in fit patients but is associated with a higher incidence of postoperative urinary retention.<sup>10</sup> If general anesthesia is used, a local anesthetic should be given at the end of the procedure as an adjuvant to reduce immediate postoperative pain. Spinal or epidural anesthesia can also be used but is less popular.

#### **Operative Technique**

The various anterior nonprosthetic herniorrhaphies have a number of initial technical steps in common; they differ primarily with respect to the specific details of the actual repair.

**Step 1: Administration of Local Anesthetic.** Generally, we use a solution containing 50 ml of 0.5% lidocaine with epinephrine and 50 ml of 0.25% bupivacaine with epinephrine; the epinephrine is optional and may be omitted in patients who have a history of coronary artery disease. In an adult of normal size, 70 ml of this solution is injected before preparation and draping: 10 ml is placed medial to the anterior superior iliac spine to block the ilioinguinal nerve, and the other 60 ml is used as a field block along the orientation of the eventual incision in the subcutaneous and deeper tissues. Care is taken to ensure that some of the material is injected into the areas of the pubic tubercle and Cooper's ligament, which are easily identified by tactile sensation (except in very obese patients). Intradermal injection is unnecessary because by the time the surgeon is scrubbed and the patient draped, anesthesia is complete. The remaining 30 ml is reserved for discretionary use during the procedure. With this technique, endotracheal intubation is avoided and the patient can be aroused from sedation periodically to perform Valsalva maneuvers to test the repair.

**Step 2: Initial Incision.** Traditionally, the skin is opened by making an oblique incision between the anterior superior iliac spine and the pubic tubercle. For cosmetic reasons, however, many surgeons now prefer a more horizontal skin incision placed in the natural skin lines. In either case, the incision is deepened through Scarpa's and Camper's fasciae and the subcutaneous tissue to expose the external oblique aponeurosis. The external oblique aponeurosis is then opened through the external inguinal ring.

**Step 3: Mobilization of Cord Structures.** The superior flap of the external oblique fascia is dissected away from the anterior rectus sheath medially and the internal oblique muscle laterally. The iliohypogastric nerve is identified at this time; it can be either left in situ or freed from the surrounding tissue and isolated from the operative field by passing a hemostat under the nerve and grasping the upper flap of the external oblique aponeurosis. Routine division of the iliohypogastric nerve along with the ilioinguinal nerve is practiced by some surgeons but is not advised by most. The cord structures are then bluntly dissected away from the inferior flap of the external oblique aponeurosis to expose the shelving edge of the inguinal ligament and the iliopubic tract. The cord structures are lifted en masse with the fingers of one hand at the pubic tubercle so that the index finger can be passed underneath to meet the ipsilateral thumb or the fingers of the other hand. Mobilization of the cord structures is completed by means of blunt dissection, and a Penrose drain is placed around them so that they can be retracted during the procedure.

**Step 4: Division of Cremaster Muscle.** Complete division of the cremaster muscle has been common practice, especially with indirect hernias. The purposes of this practice are to facilitate identification of the sac and to lengthen the cord for better visualization of the inguinal floor. Almost always, however, adequate exposure can be obtained by opening the muscle longitudinally, which reduces the chances of damage to the cord and prevents testicular descent. Accordingly, the latter approach should be considered best practice unless there are extenuating circumstances.

**Step 5: High Ligation of Sac.** The term high ligation of the sac is used frequently in discussing hernia repair; its historical significance has ingrained it in the descriptions of most of the older operations. For our purposes in this chapter, high ligation of the sac should be considered equivalent to reduction of the sac into the preperitoneal space without excision. The two methods work equally well and are highly effective. Some surgeons believe that sac inversion results in less pain (because the richly innervated peritoneum is not incised) and may be less likely to cause adhesive complications. To date, however, no randomized trials have been done to determine whether this is so.<sup>11</sup> Sac eversion in lieu of excision does protect intra-abdominal viscera in cases of unrecognized incarcerated sac contents or sliding hernia.

**Step 6: Management of Inguinal Scrotal Hernial Sacs.** Some surgeons consider complete excision of all indirect inguinal hernial sacs important. The downside of this practice is that the incidence of ischemic orchitis from excessive trauma to the cord rises substantially. The logical sequela of ischemic orchitis is testicular atrophy, though this presumed relationship has not been conclusively proved. In our view, it is better to divide an indirect inguinal hernial sac in the midportion of the inguinal canal once it is clear that the hernia is not sliding and no abdominal contents are present. The distal sac is not removed, but its anterior wall is opened as far distally as is convenient. Contrary to the opinion commonly voiced in the urologic literature, this approach does not result in excessive postoperative hydrocele formation.

**Step 7: Repair of Inguinal Floor.** Methods of repairing the inguinal floor differ significantly among the various repairs and thus are described separately [*see Details of Specific Repairs -- omitted, below*].

**Step 8: Relaxing Incision.** A relaxing incision is made through the anterior rectus sheath and down to the rectus abdominis, extending superiorly from the pubic tubercle for a variable distance, as determined by the degree of tension present. Some surgeons prefer to "hockey-stick" the incision laterally at the superior end. The posterior rectus sheath is strong enough to prevent future incisional herniation. This relaxing incision works because as the anterior rectus sheath separates, the various components of the abdominal wall are displaced laterally and inferiorly.

**Step 9: Closure.** Closure of the external oblique fascia serves to reconstruct the superficial (external) ring. The external ring must be loose enough to prevent strangulation of the cord structures yet tight enough to ensure that an inexperienced examiner will not confuse a dilated ring with a recurrence. A dilated external ring is sometimes referred to as an industrial hernia, because over the years it has occasionally been a problem during preemployment physical examinations. Scarpa's fascia and the skin are closed to complete the operation.

**Marcy repair.** The Marcy repair is the simplest nonprosthetic repair performed today. Its main indication is for treatment of Nyhus type 1 hernias (i.e., indirect inguinal hernias in which the internal ring is normal). It is appropriate for children and young adults in whom there is concern about the long-term effects of prosthetic material. The essential features of the Marcy repair are high ligation of the sac and narrowing of the internal ring. Displacing the cord structures laterally allows the placement of sutures through the muscular and fascial layers [*see Figure 4 -- omitted*].

**Bassini repair.** Edoardo Bassini (1844–1924) is considered the father of modern inguinal hernia surgery. By combining high ligation of a hernial sac with reconstruction of the inguinal floor and taking advantage of the developing disciplines of antisepsis and anesthesia, he was able to reduce morbidity and mortality substantially. Before Bassini's achievements, elective herniorrhaphy was almost never recommended, because the results were so bad. Bassini's operation, known as the radical cure, became the gold standard for inguinal hernia repair for most of the 20th century.

The initial steps in the procedure are essentially as already described (see above). Bassini felt that the incision in the external oblique aponeurosis should be as superior as possible while still allowing the superficial external ring to be opened,<sup>12</sup> so that the reapproximation suture line created later in the operation would not be directly over the suture line of the inguinal floor

reconstruction. Whether this technical point is significant is debatable. Bassini also felt that lengthwise division of the cremaster muscle followed by resection was important for ensuring that an indirect hernial sac could not be missed and for achieving adequate exposure of the inguinal floor.

After performing the initial dissection and the reduction or ligation of the sac, Bassini began the reconstruction of the inguinal floor by opening the transversalis fascia from the internal inguinal ring to the pubic tubercle, thereby exposing the preperitoneal fat, which was bluntly dissected away from the undersurface of the superior flap of the transversalis fascia [see *Figure 5a -- omitted*]. This step allowed him to properly prepare the deepest structure in his famous "triple layer" (comprising the transversalis fascia, the transversus abdominis, and the internal oblique muscle).

The first stitch in Bassini's repair includes the triple layer superiorly and the periosteum of the medial side of the pubic tubercle, along with the rectus sheath. In current practice, however, most surgeons try to avoid the periosteum of the pubic tubercle so as to decrease the incidence of osteitis pubis. The repair is then continued laterally, and the triple layer is secured to the reflected inguinal ligament (Poupart's ligament) with nonabsorbable sutures. The sutures are continued until the internal ring is closed on its medial side [see *Figure 5b -- omitted*]. A relaxing incision was not part of Bassini's original description but now is commonly added.

Concerns about injuries to neurovascular structures in the preperitoneal space as well as to the bladder led many surgeons, especially in North America, to abandon the opening of the transversalis fascia. The unfortunate consequence of this decision is that the proper development of the triple layer is severely compromised. In lieu of opening the floor, a forceps (e.g., an Allis clamp) is used to grasp tissue blindly in the hope of including the transversalis fascia and the transversus abdominis. The layer is then sutured, along with the internal oblique muscle, to the reflected inguinal ligament as in the classic Bassini repair. The structure grasped in this modified procedure is sometimes referred to as the conjoined tendon, but this is not correct because of the variability in what is actually grasped in the clamp. This imprecise "good stuff to good stuff" approach almost certainly accounts for the inferior results achieved with the Bassini procedure in the United States.

**Maloney darn.** The Maloney darn gets its name from the way in which a long nylon suture is repeatedly passed between the tissues to create a weave that one might consider similar to a mesh. After initial preparation of the groin (see above), a continuous nylon suture is used to oppose the transversus abdominis, the rectus abdominis, the internal oblique muscle, and the transversalis fascia medially to Poupart's ligament laterally. The suture is continued into the muscle around the cord and is woven in and out to form a reinforcement around the cord. On the lateral side of the cord, it is sutured to the inguinal ligament and tied. The darn is a second layer. The sutures are placed either parallel or in a criss-cross fashion and are plicated well into the inguinal ligament below. The darn must be carried well over the medial edge of the inguinal canal. Once the darn is complete, the external oblique muscle is closed over the cord structures. The Maloney darn can be considered a forerunner of the mesh repairs, in that the purpose of the darn is to provide a scaffold for tissue ingrowth.<sup>13</sup>

**Shouldice repair.** Steps 1 through 6 are performed essentially as previously described (see above). Particular importance is placed on freeing of the cord from its surrounding adhesions, resection of the cremaster muscle, high dissection of the hernial sac, and division of the transversalis fascia during the initial steps of the procedure.<sup>14</sup> A continuous nonabsorbable suture (typically of monofilament steel wire) is used to repair the floor. The Shouldice surgeons believe that a continuous suture distributes tension evenly and prevents potential defects between interrupted sutures that could lead to recurrence.

The repair is started at the pubic tubercle by approximating the iliopubic tract laterally to the undersurface of the lateral edge of the rectus abdominis [see *Figure 6a -- omitted*]. The suture is continued laterally, approximating the iliopubic tract to the medial flap, which is made up of the transversalis fascia, the internal oblique muscle, and the transversus abdominis. Eventually, four suture lines are developed from the medial flap. The continuous suture is extended to the internal ring, where the lateral stump of the cremaster muscle is picked up to form a new internal ring. Next, the direction of the suture is reversed back toward the pubic tubercle, approximating the medial edges of the internal oblique muscle and the transversus abdominis to Poupart's ligament, and the wire is tied to itself and then to the first knot [see *Figure 6b -- omitted*]. Thus, two suture lines are formed by the first suture.

A second wire suture is started near the internal ring, approximating the internal oblique muscle and the transversus abdominis to a band of external oblique aponeurosis superficial and parallel to Poupart's ligament—in effect, creating a second, artificial Poupart's ligament. This third suture line ends at the pubic crest. The suture is then reversed, and a fourth suture line is constructed in a similar manner, superficial to the third line. At the Shouldice clinic, the cribriform fascia is always incised in the thigh, parallel to the inguinal ligament, to make the inner side of the lower flap of the external oblique aponeurosis available for these multiple layers. In general practice, however, this step is commonly omitted.

The results at the Shouldice clinic have been truly outstanding and continue to be so today. For a time, the Shouldice repair was the gold standard against which all newer procedures were compared. The major criticism of this operation is that it is difficult to teach because surgeons have

problems understanding what is really being sewn to what. Unless one is specifically trained at the Shouldice clinic and has the opportunity to work with the surgeons there, one may find it hard to identify the various layers in the medial flap reliably and reproducibly—a step that is crucial for developing the multiple suture lines. To compound the difficulty, modifications developed outside the Shouldice clinic have given rise to different versions of the procedure. For example, some surgeons use three continuous layers instead of four for reconstruction of the inguinal floor.

**McVay Cooper's ligament repair.** This operation is similar to the Bassini repair, except that it uses Cooper's ligament instead of the inguinal ligament for the medial portion of the repair. Interrupted sutures are placed from the pubic tubercle laterally along Cooper's ligament, progressively narrowing the femoral ring; this constitutes the most common application of the repair—namely, treatment of a femoral hernia [see *Figure 7 -- omitted*]. The last stitch in Cooper's ligament is known as a transition stitch and includes the inguinal ligament. This stitch has two purposes: (1) to complete the narrowing of the femoral ring by approximating the inguinal ligament to Cooper's ligament, as well as to the medial tissue, and (2) to provide a smooth transition to the inguinal ligament over the femoral vessel so that the repair can be continued laterally (as in a Bassini repair). Given the considerable tension required to bridge such a large distance, a relaxing incision should always be used. In the view of many authorities, this tension results in more pain than is noted with other herniorrhaphies and predisposes to recurrence. For this reason, the McVay repair is rarely chosen today, except in patients with a femoral hernia or patients with a specific contraindication to mesh repair.

**Subinguinal femoral hernia repair.** Femoral hernias in females can easily be approached via a groin incision with dissection into the fossa ovalis beneath the inguinal ligament without the external oblique fascia being opened. The defect can be either closed with sutures or bridged with a mesh plug prosthesis [see *Figure 8 -- omitted*]. Larger femoral hernias in females and all femoral hernias in males are better treated with a McVay Cooper's ligament repair.

**Pediatric hernia repair.** Children and young adults commonly present with an indirect sac only, with no discernible destruction of the inguinal floor. An extensive repair is not indicated: nearly all such patients are cured with sac ligation or eversion alone. A Marcy repair is the most extensive procedure that should be considered in this population.

## Inguinal Herniorrhaphy: Conventional Anterior Prosthetic Repairs

### *Lichtenstein Repair*

**Steps 1 through 6.** The first six steps of a Lichtenstein repair are very similar to the first six steps of a conventional anterior nonprosthetic repair [see *Inguinal Herniorrhaphy: Conventional Anterior Nonprosthetic Repairs -- omitted, above*], but there are certain technical points that are worthy of emphasis. The external oblique aponeurosis is generously freed from the underlying anterior rectus sheath and internal oblique muscle and aponeurosis in an avascular plane from a point at least 2 cm medial to the pubic tubercle to the anterior superior iliac spine laterally. Blunt dissection is continued in this avascular plane from the area lateral to the internal ring to the pubic tubercle along the shelving edge of the inguinal ligament and the iliopubic tract. As a continuation of this same motion, the cord with its cremaster covering is swept off the pubic tubercle and separated from the inguinal floor. Besides mobilizing the cord, these maneuvers create a large space beneath the external oblique aponeurosis that can eventually be used for prosthesis placement. The ilioinguinal nerve, the external spermatic vessels, and the genital branch of the genitofemoral nerve all remain with the cord structures.

For indirect hernias, the cremaster muscle is incised longitudinally, and the sac is dissected free and reduced into the preperitoneal space. Theoretically, this operation could be criticized on the grounds that if the inguinal floor is not opened, an occult femoral hernia might be overlooked. To date, however, an excessive incidence of missed femoral hernias has not been reported. In addition, it is possible to evaluate the femoral ring via the space of Bogros through a small opening in the canal floor.

Direct hernias are separated from the cord and other surrounding structures and reduced back into the preperitoneal space. Dividing the superficial layers of the neck of the sac circumferentially—which, in effect, opens the inguinal floor—usually facilitates reduction and helps maintain it while the prosthesis is being placed. This opening in the inguinal floor also allows the surgeon to palpate for a femoral hernia. Sutures can be used to maintain reduction of the sac, but they have no real strength in this setting; their main purpose is to allow the repair to proceed without being hindered by continual extrusion of the sac into the field, especially when the patient strains.

**Step 7: Placement of Prosthesis.** A mesh prosthesis is positioned over the inguinal floor. For an adult, the prosthesis should be at least 15 × 8 cm. The medial end is rounded to correspond to the patient's particular anatomy and secured to the anterior rectus sheath at least 2 cm medial to the pubic tubercle. A continuous suture of either nonabsorbable or long-lasting absorbable material should be used. Wide overlap of the pubic tubercle is important to prevent the pubic tubercle recurrences all too commonly seen with other operations. The suture is continued laterally in a locking fashion, securing the prosthesis to either side of the pubic tubercle (not into it) and then to the shelving edge of the inguinal ligament. The suture is tied at the internal ring.

**Step 8: Creation of Shutter Valve.** A slit is made at the lateral end of the mesh in such a way as to create two tails, a wider one (approximately two thirds of the total width) above and a narrower one below. The tails are positioned around the cord structures and placed beneath the external oblique aponeurosis laterally to about the anterior superior iliac spine, with the upper tail placed on top of the lower. A single interrupted suture is placed to secure the lower edge of the superior tail to the lower edge of the inferior tail—in effect, creating a shutter valve. This step is considered crucial for preventing the indirect recurrences occasionally seen when the tails are simply reapproximated. The same suture incorporates the shelving edge of the inguinal ligament so as to create a domelike buckling effect over the direct space, thereby ensuring that there is no tension, especially when the patient assumes an upright position. The Lichtenstein group has now developed a customized prosthesis with a built-in domelike configuration, which, in their view, makes suturing the approximated tails to the inguinal ligament unnecessary.

**Step 9: Securing of Prosthesis.** A few interrupted sutures are placed to attach the superior and medial aspects of the prosthesis to the underlying internal oblique muscle and rectus fascia [see *Figure 9 -- omitted*]. On occasion, the iliohypogastric nerve, which courses on top of the internal oblique muscle, penetrates the medial flap of the external oblique aponeurosis. In this situation, the prosthesis should be slit to accommodate the nerve. The prosthesis can be trimmed in situ, but care should be taken to maintain enough laxity to allow for the difference between the supine and the upright positions, as well as for possible shrinkage of the mesh.

**Step 10: Repair of Femoral Hernia.** If a femoral hernia is present, the posterior surface of the mesh is sutured to Cooper's ligament after the inferior edge has been attached to the inguinal ligament, thereby closing the femoral canal.

**Step 11: Closure.** Closure is accomplished in the same manner as in a conventional anterior nonprosthetic repair.

### ***Plug-and-Patch Repair***

The mesh plug technique was first developed by Gilbert and subsequently modified by Rutkow and Robbins, Millikan, and others [see *Figure 10 -- omitted*].<sup>15-17</sup> The groin is entered via a standard anterior approach. The hernial sac is dissected away from surrounding structures and reduced into the preperitoneal space. A flat sheet of polypropylene mesh is rolled up like a cigarette, tied, inserted in the defect, and secured with interrupted sutures to either the internal ring (for an indirect hernia) or the neck of the defect (for a direct hernia).

A prefabricated prosthesis that has the configuration of a flower is commercially available and is recommended by Rutkow and Robbins. This prosthesis is tailored to each patient's particular anatomy by removing some of the "petals" to avoid unnecessary bulk. Many surgeons consider this step important for preventing erosion into surrounding structures (e.g., the bladder); indeed, such complications have been reported, albeit rarely.

Millikan further modified the procedure by recommending that the inside petals be sewn to the ring of the defect. For an indirect hernia, the inside petals are sewn to the internal oblique portion of the internal ring, which forces the outside of the prosthesis underneath the inner side of the defect and makes it act like a preperitoneal underlay. For direct hernias, the inside petals are sewn to Cooper's ligament and the shelving edge of the inguinal ligament is sewn to the conjoined tendon, which, again, forces the outside of the prosthesis to act as an underlay.

The patch portion of the procedure is optional and involves placing a flat piece of polypropylene in the conventional inguinal space so that it widely overlaps the plug, much as in a Lichtenstein repair. The difference with a plug-and-patch repair is that only one or two sutures—or even, perhaps, no sutures—are used to secure the flat prosthesis to the underlying inguinal floor. Some surgeons, however, place so many sutures that they have in effect performed a Lichtenstein operation on top of the plug—a procedure sometimes referred to as a "plugstenstein."

To the credit of its proponents, the plug-and-patch repair, in all of its varieties, has been skillfully presented and has rapidly taken a significant share of the overall inguinal hernia market. It is not only fast but also extremely easy to teach, which has made it popular in both private and academic centers.

### **Inguinal Herniorrhaphy: Preperitoneal Nonprosthetic Repairs**

A key technical issue in a preperitoneal hernia repair is how the surgeon chooses to enter the preperitoneal space. In fact, within this general class of repair, the method of entry into this space constitutes the major difference between the various procedures.

Many approaches to the preperitoneal space have been described. For example, the space can be entered either anteriorly or posteriorly. If an anterior technique is to be used, the initial steps of the operation are similar to those of a conventional anterior herniorrhaphy. If a posterior technique is to be used, any of several incisions (lower midline, paramedian, or Pfannenstiel) will allow an extraperitoneal dissection. The preperitoneal space can also be entered transabdominally. This is useful when the patient is undergoing a laparotomy for some other condition and the hernia is to be repaired incidentally. Of course, the transabdominal preperitoneal laparoscopic repairs described elsewhere [see *5:28 Laparoscopic Hernia Repair -- omitted*], by definition, enter the preperitoneal

space from the abdomen.

Reed credits Annandale as being the first surgeon to describe the anterior method of gaining access to the preperitoneal space.<sup>18</sup> Bassini's operation, as classically performed, is technically an anterior preperitoneal operation, but it is never discussed in this group, because in the American variant of the procedure, the preperitoneal space is not entered. Cheatle suggested the posterior approach to the preperitoneal space for repair of an inguinal hernia but used a laparotomy to do it.<sup>19</sup> Cheatle and Henry subsequently modified the operation so as to render it entirely extraperitoneal (the so-called Cheatle-Henry approach), which made the procedure more acceptable to surgeons.<sup>20</sup>

The preperitoneal nonprosthetic method remained popular into the second half of the 20th century, championed by proponents such as Nyhus and Condon, who emphasized the importance of the iliopubic tract as the inferior border in primary closures of direct or indirect hernia defects.<sup>21</sup> Today, however, these operations are of little more than historical significance, because it is now universally agreed that better results are obtained in this space when a prosthesis is used. Indeed, after 1975, Nyhus and Condon began routinely placing a 6 × 14 cm piece of polypropylene mesh to buttress the primary repair in all patients with recurrent hernias.<sup>22</sup> When contraindications to a prosthesis are present [see *Table 4 -- omitted*], most surgeons would opt for a conventional anterior herniorrhaphy (e.g., a Bassini or Shouldice repair) rather than a preperitoneal nonprosthetic herniorrhaphy.

### **Inguinal Herniorrhaphy: Preperitoneal Prosthetic Repairs**

The most important step in any preperitoneal prosthetic repair is the placement of a large prosthesis in the preperitoneal space on the abdominal side of the defect in the transversalis fascia. The theoretical advantage of this measure is that whereas in a conventional repair abdominal pressure might contribute to recurrence, in a preperitoneal repair, the abdominal pressure would actually help fix the mesh material against the abdominal wall, thereby adding strength to the repair. The hernia defect itself may or may not be closed, depending on the preference of the surgeon. The strength of the repair depends on the prosthesis rather than on closure of the defect; however, such closure may decrease the seroma formation that inevitably occurs at the site of the undisturbed residual sac. Although these seromas almost always are self-limited and disappear with time, they can be confused with recurrences by both patients and referring physicians. Accordingly, some surgeons prefer to take every step possible to prevent them.

#### **Anterior Approach**

**Read-Rives Repair.** The initial part of a Read-Rives repair, including the opening of the inguinal floor, is much like that of a classic Bassini repair. The inferior epigastric vessels are identified and the preperitoneal space completely dissected. The spermatic cord is parietalized by separating the ductus deferens from the spermatic vessels. A 12 × 16 cm piece of mesh is positioned in the preperitoneal space deep to the inferior epigastric vessels and secured with three sutures placed in the pubic tubercle, in Cooper's ligament, and in the psoas muscle laterally. The transversalis fascia is closed over the prosthesis and the cord structures replaced. The rest of the closure is accomplished much as in a conventional anterior prosthetic repair.

#### **Posterior Approach**

**Stoppa-Rignault-Wantz Repair (Giant Prosthetic Reinforcement of Visceral Sac).** GPRVS has its roots in the important contribution that Henri Fruchaud made to herniology. In describing the myopectineal orifice that bears his name [see *Figure 11 -- omitted*], Fruchaud, who was Stoppa's mentor, popularized a different approach to the etiology of inguinal hernias.<sup>23</sup> Instead of subdividing hernias into direct, indirect, and femoral and then examining their specific causes, he emphasized that the common cause of all inguinal hernias was the failure of the transversalis fascia to retain the peritoneum. This concept led Stoppa to develop GPRVS, which reestablishes the integrity of the peritoneal sac by inserting a large permanent prosthesis that entirely replaces the transversalis fascia over the myopectineal orifice of Fruchaud with wide overlapping of surrounding tissue. With GPRVS, the exact type of hernia present (direct, indirect, or femoral) is unimportant, because the abdominal wall defect is not addressed.

**Step 1: skin incision.** A lower midline, inguinal, or Pfannenstiel incision can be used, depending on the surgeon's preference. The inguinal incision is placed 2 to 3 cm below the level of the anterior superior iliac spine but above the internal ring; it is begun at the midline and extended laterally for 8 to 9 cm.<sup>24</sup>

**Step 2: preperitoneal dissection.** The fascia overlying the space of Retzius is opened without violation of the peritoneum. A combination of blunt and sharp dissection is continued laterally posterior to the rectus abdominis and the inferior epigastric vessels. The preperitoneal space is completely dissected to a point lateral to the anterior superior iliac spine [see *Figure 12 -- omitted*]. The symphysis pubis, Cooper's ligament, and the iliopubic tract are identified. Inferiorly, the peritoneum is generously dissected away from the vas deferens and the internal spermatic vessels to create a large pocket, which will eventually accommodate a prosthesis without the possibility of

rollup. In the inguinal approach, the anterior rectus sheath and the oblique muscles are incised for the length of the skin incision. The lower flaps of these structures are retracted inferiorly toward the pubis. The transversalis fascia is incised along the lateral edge of the rectus abdominis, and the preperitoneal space is entered; dissection then proceeds as previously indicated.

**Step 3: management of hernial sac.** Direct hernial sacs are reduced during the course of the preperitoneal dissection. Care must be taken to stay in the plane between the peritoneum and the transversalis fascia, allowing the latter structure to retract into the hernia defect toward the skin. The transversalis fascia can be thin, and if it is inadvertently opened and incorporated with the peritoneal sac during reduction, a needless and bloody dissection of the abdominal wall is the result.

Indirect sacs are more difficult to deal with than direct sacs are, in that they often adhere to the cord structures. Trauma to the cord must be minimized to prevent damage to the vas deferens or the testicular blood supply. Small sacs should be mobilized from the cord structures and reduced back into the peritoneal cavity. Large sacs may be difficult to mobilize from the cord without undue trauma if an attempt is made to remove the sac in its entirety. Accordingly, large sacs should be divided, with the distal portion left in situ and the proximal portion dissected away from the cord structures. Division of the sac is most easily accomplished by opening the sac on the side opposite the cord structures. A finger is placed in the sac to facilitate its separation from the cord. Downward traction is then placed on the cord structures to reduce any excessive fatty tissue (so-called lipoma of the cord) back into the preperitoneal space. This step prevents the "pseudorecurrences" that may occur if the abnormality palpated during the preoperative physical examination was not a hernia but a lipoma of the cord.

**Step 4: management of abdominal wall defect.** It is this step that varies most from one author to another. In Nyhus's approach, the defect is formally repaired, and only then is a tailored mesh prosthesis sutured to Cooper's ligament and the transversalis fascia for reinforcement [see *Figure 13 -- omitted*]. In Rignault's approach, the defect is loosely closed to prevent an unsightly early postoperative bulge.<sup>25</sup> In Stoppa's and Wantz's approaches, the defect is usually left alone, but the transversalis fascia in the defect is occasionally plicated by suturing it to Cooper's ligament to prevent the bulge caused by a seroma in the undisturbed sac.

**Step 5: parietalization of spermatic cord.** The term parietalization of the spermatic cord, [see *Video 1 -- omitted*] popularized by Stoppa, refers to a thorough dissection of the cord aimed at providing sufficient length to permit lateral movement of the structure [see *Figure 14 -- omitted*]. In Stoppa's view, this step is essential, in that it allows a prosthesis to be placed without having to be split laterally to accommodate the cord structures; the keyhole defect created when the prosthesis is split has been linked with recurrences. In Rignault's view, on the other hand, creation of a keyhole defect in the mesh to encircle the spermatic cord is preferable, the rationale being that this gives the prosthesis enough security to allow the surgeon to dispense with fixation sutures or tacks. Minimizing fixation in this area is important because of the numerous anatomic elements in the preperitoneal space that can be inadvertently damaged during suture placement.

**Step 6: placement of prosthesis.** Dacron mesh, being more pliable than polypropylene, conforms well to the preperitoneal space and is therefore considered particularly suitable for GPRVS.

Stoppa's technique is most often associated with a single large prosthesis for bilateral hernias. The prosthesis is cut in the shape of a chevron [see *Figure 15a -- omitted*], and eight clamps are positioned strategically around the prosthesis to facilitate placement into the preperitoneal space [see *Figure 15b -- omitted*].

Unilateral repairs require a prosthesis that is approximately 15 × 12 cm but is cut so that the bottom edge is wider than the top edge and the lateral side is longer than the medial side. In Wantz's technique, three absorbable sutures are used to attach the superior border of the prosthesis to the anterior abdominal wall well above the defect [see *Figure 16 -- omitted*]. The sutures are placed from medial to lateral near the linea alba, the semilunar line, and the anterior superior iliac spine. A Reverdin suture needle facilitates this task. Three long clamps are then placed on each corner and the middle of the prosthesis of the inferior flap. The medial clamp is placed into the space of Retzius and held by an assistant. The middle clamp is positioned so that the mesh covers the pubic ramus, the obturator fossa, and the iliac vessels and is also held by the assistant. The lateral clamp is placed into the iliac fossa to cover the parietalized cord structures and the iliopsoas muscle. Care must be taken to prevent the prosthesis from rolling up as the clamps are removed.

**Step 7: closure of the wound.** The surgical wound is closed along anatomic guidelines once the surgeon is assured that there has been no displacement or rollup of the prosthesis.

### **Kugel and Ugahary Repairs**

The Kugel and Ugahary repairs were developed to compete with laparoscopic repairs. They require only a small (2 to 3 cm) skin incision placed 2 to 3 cm above the internal ring.<sup>26,27</sup> In Kugel's operation, the incision is oriented obliquely, with one third of the incision lateral to a point halfway between the anterior superior iliac spine and the pubic tubercle and the remaining two thirds medial to this point. The incision is deepened through the external oblique fascia, and the internal oblique muscle is bluntly spread apart. The transversalis fascia is opened vertically for a distance of about 3 cm, but the internal ring is not violated. The preperitoneal space is entered and a blunt dissection

performed. The inferior epigastric vessels are identified to confirm that the dissection is being done in the correct plane. These vessels should be left adherent to the overlying transversalis fascia and retracted medially and anteriorly. The iliac vessels, Cooper's ligament, the pubic bone, and the hernia defect are identified by palpation. Most hernial sacs are simply reduced; the exceptions are large indirect sacs, which must sometimes be divided, with the distal sac left in situ and the proximal sac closed. To prevent recurrences, the cord structures are thoroughly parietalized to allow adequate posterior dissection.

The key to Kugel's procedure is a specially designed 8 × 12 cm prosthesis made of two pieces of polypropylene with a single extruded monofilament fiber located near its edge. The construction of the prosthesis allows it to be deformed so that it can fit through the small incision; once inserted, it springs open to regain its normal shape, providing a wide overlap of the myopectineal orifice. The prosthesis also has a slit on its anterior surface, through which the surgeon places a finger to facilitate positioning.

Ugahary's operation is similar to Kugel's, but it does not require a special prosthesis. In what is known as the gridiron technique, the preperitoneal space is prepared through a 3 cm incision, much as in a Kugel repair. The space is held open with a narrow Langenbeck retractor and two ribbon retractors. A 10 × 15 cm piece of polypropylene mesh is rolled onto a long forceps after the edges have been rounded and sutures placed to correspond to various anatomic landmarks. The forceps with the rolled-up mesh on it is introduced into the preperitoneal space, and the mesh is unrolled with the help of clamps and specific movements of the ribbon retractors.

Both operations have been very successful in some hands and have important proponents. However, because they are essentially blind repairs, considerable experience with them is required before the surgeon can be confident in his or her ability to place the patch properly.

### **Combined Anterior-Posterior Approach**

**Bilayer Prosthetic Repair.** The bilayer prosthetic repair involves the use of a dumbbell-shaped prosthesis consisting of two flat pieces of polypropylene mesh connected by a cylinder of the same material. The purpose of this design is to allow the surgeon to take advantage of the presumed benefits of both anterior and posterior approaches by placing prosthetic material in both the preperitoneal space and the extraperitoneal space.

The initial steps are identical to those of a Lichtenstein repair. Once the conventional anterior space has been prepared, the preperitoneal space is entered through the hernia defect. Indirect hernias are reduced, and a gauze sponge is used to develop the preperitoneal space through the internal ring. For direct hernias, the transversalis fascia is opened, and the space between this structure and the peritoneum is developed with a gauze sponge. The deep layer of the prosthesis is deployed in the preperitoneal space, overlapping the direct and indirect spaces and Cooper's ligament. The superficial layer of the device occupies the conventional anterior space, much as in a Lichtenstein repair. It is slit laterally or centrally to accommodate the cord structures and then affixed to the area of the pubic tubercle, the middle of the inguinal ligament, and the internal oblique muscle with three or four interrupted sutures.

### **Inguinal Herniorrhaphy: Complications**

#### **Postherniorrhaphy Groin Pain**

It is generally recognized that inguinal herniorrhaphy results in greater morbidity than was previously appreciated. Now that modern hernioplasty techniques have reduced recurrence rates to a minimum, chronic postoperative groin pain syndromes have emerged as the major complication facing inguinal hernia surgeons. In a critical review of inguinal herniorrhaphy studies between 1987 and 2000, the incidence of some degree of long-term groin pain after surgery was as high as 53% at 1 year (range, 0% to 53%).<sup>28</sup> In the absence of a standard raw database, it was somewhat difficult to extrapolate from these data, but the best estimate was that moderate to severe pain occurred in about 10% of patients and some degree of restriction of activity in about 25%.

Various postherniorrhaphy groin pain syndromes may develop, usually as a consequence of scarring, reaction to prosthetic material, or incorporation of a nerve in staples or suture material during the repair. Chronic postoperative groin pain occurs without regard to the type of repair performed. It can be classified into three general types, as follows:

1. Somatic (nociceptive) pain, the most common form, includes ongoing preoperative pathologic states that were the real causes of patients' pain preoperatively, usually related to ligament or muscle injury; new ligament or muscle injury caused by the operation; scar tissue; osteitis pubis; and reaction to prosthetic material.
2. Neuropathic pain is related to direct nerve damage. Accurate diagnosis is important because if the cause of pain is incorporation of a nerve in staples or sutures, effective surgical treatment is available. The nerves usually involved are the ilioinguinal nerve, the iliohypogastric nerve, the genitofemoral nerve, and the lateral cutaneous nerve of the thigh. The first two nerves are especially likely to be injured during a conventional herniorrhaphy, whereas the latter two are more likely to be damaged

during a preperitoneal herniorrhaphy. Femoral nerve injury, fortunately, is extremely rare and is usually the result of a gross technical misadventure. Neuropathy is generally signaled by pain or paresthesia in the injured nerve's distribution; however, there is significant overlap in the distributions of these nerves, and as a result, it is frequently difficult to determine exactly which nerve is damaged.

3. Visceral pain is related to specific visceral functions; common examples are pain with urination and the dysejaculation syndrome.

Perhaps the most important single issue in dealing with postherniorrhaphy pain is whether the current pain is the same as or different from the pain that brought the hernia to the attention of the physician in the first place. If the latter is the case, efforts must be made to determine which of the numerous potential causative conditions is responsible. Computed tomography, ultrasonography, herniography, laparoscopy, and magnetic resonance imaging all are of diagnostic value in this setting. Of these, MRI has emerged as the most useful because of its ability to differentiate between muscle tears, osteitis pubis, bursitis, and stress fracture. A strain of the adductor muscle complex (comprising the adductor longus, the adductor brevis, the adductor magnus, and the gracilis) is a commonly overlooked cause of pain.

Treatment is difficult and often fails entirely. The difficulty is compounded when workers' compensation issues cloud the picture. The first possibility that must be ruled out is a recurrent hernia. As a rule, all three types of pain are best treated initially with reassurance and conservative treatment (e.g., anti-inflammatory medications and local nerve blocks); frequently, the complaint resolves spontaneously. The only exception to this rule might be the patient who complains of severe pain immediately (i.e., in the recovery room), who might be best treated with immediate reexploration before scar tissue develops. Otherwise, we scrupulously avoid reexploration in the first year after the procedure to allow for the possibility of spontaneous resolution. When groin exploration is required, neurectomy and neuroma excision, adhesiolysis, muscle or tendon repair, and foreign-body removal are all possibilities. The results are often less than satisfying.

### ***Ischemic Orchitis and Testicular Atrophy***

Orchitis or atrophy may result if the testicular blood supply is compromised during herniorrhaphy. Orchitis is defined as postoperative inflammation of the testicle occurring within the first 2 postoperative days. Patients experience painful enlargement and hardening of the testicle, usually associated with a low-grade fever; the pain is severe and may last several weeks. Ischemic orchitis is most likely attributable to thrombosis of the veins draining the testicle, caused by dissection of the spermatic cord. It may progress over a period of months and eventually result in testicular atrophy. This latter development is not inevitable, however. In fact, the occurrence of testicular atrophy is quite unpredictable, in that most patients with this condition have no history of any testicular problems associated with the index herniorrhaphy. Overall, the vast majority of patients who experience testicular problems as an immediate complication of herniorrhaphy go on to recover without atrophy. Bendavid, in a study of the incidence of testicular atrophy at the Shouldice Hospital, found that this complication occurred in only 19 (0.036%) of 52,583 primary inguinal hernia repairs and in only 33 (0.46%) of 7,169 recurrent inguinal hernia repairs.<sup>29</sup>

### ***Hemorrhage***

Postherniorrhaphy bleeding—usually the result of delayed bleeding from the cremasteric artery, the internal spermatic artery, or branches of the inferior epigastric vessels—can produce a wound or scrotal hematoma. Injuries to the deep circumflex artery, the corona mortis, or the external iliac vessels may result in a large retroperitoneal hematoma.

### ***Osteitis Pubis***

Osteitis pubis has diminished in frequency since surgeons began to realize the importance of not placing sutures through the periosteum. In laparoscopic repairs, staples are used to attach the mesh to Cooper's ligament, which may cause osteitis in some cases.

### ***Prosthesis-Related Complications***

The increasingly liberal use of prosthetic material in conventional herniorrhaphy and the routine use of such material in laparoscopic herniorrhaphy make the discussion of complications related directly to foreign material a timely one. Tissue response, which is variable from person to person, can be so intense that the prosthetic material is deformed by contraction. Erosion can result in intestinal obstruction or fistulization, especially if there is physical contact between intestine and prosthesis.<sup>30,31</sup> Erosion into the cord structures has also been reported.<sup>32</sup>

### ***Infection***

The prostheses used for inguinal herniorrhaphies, unlike those used for ventral herniorrhaphies, rarely become infected. The reasons why the groin is apparently a protected area are unclear. When infections do occur in the groin, they can occasionally be successfully treated with drainage and prolonged antibiotic therapy; more often, however, the prosthesis must be removed. Rejection of the prosthesis because of an allergic response is possible but extremely rare. What patients call rejection in their histories is usually the result of infection.

## Incisional Herniorrhaphy

Incisional hernias occur as a complication of previous surgery. They may be caused by poor surgical technique, rough handling of tissues, use of rapidly degraded absorbable suture materials for closing the abdomen, closure of the abdomen under tension, and infection (with or without clinical wound dehiscence).<sup>33</sup> Male sex, advanced age, morbid obesity, abdominal distention, cigarette smoking, pulmonary disease, and hypoalbuminemia have all been incriminated as associated predisposing conditions, but the exact nature of these associations has never been studied in well-controlled trials. Most authorities believe that the best way of preventing incisional hernias is to close abdominal wounds with continuous nonabsorbable monofilament sutures. This is a contentious issue among surgeons, because some feel that the new longer-lasting absorbable sutures are just as good and are less likely to cause suture sinus formation, which is reported in as many as 9% of patients whose abdomens are closed with a nonabsorbable suture.<sup>34</sup>

In 2000, a systematic review and meta-analysis of randomized controlled trials was published that used the MEDLINE and Cochrane Library databases in an effort to determine which suture material and technique best reduced the risk of incisional hernia.<sup>35</sup> The incidence of incisional hernia was significantly lower when nonabsorbable sutures were used in a continuous closure; however, the incidence of suture sinus formation and that of wound pain were significantly higher. The incidence of wound dehiscence or wound infection was not affected by suture material or closure method. Subgroup analyses of individual sutures showed no significant difference in incisional hernia rates between polydioxanone and polypropylene; however, rates were noticeably higher with polyglactin. The authors concluded that surgical practice in this area depended far more on tradition than on high-quality level I scientific evidence.

Continuous suturing is faster, and there has never been convincing evidence that it is inferior to interrupted fascial closure; accordingly, it is favored by most surgeons. In a continuous closure, stitches should be placed 1 cm away from the edge and 1 cm apart from each other. To prevent excessive tension, the length of the suture should be four times the length of the wound.<sup>36</sup> The abdominal wall may be closed with a mass technique, whereby the peritoneum and the anterior and posterior muscle sheaths are fused as a single layer.<sup>37</sup> Alternatively, a multilayered approach may be considered.

The incidence of incisional herniation depends on how the condition is defined. The best definition is any abdominal wall gap, with or without a bulge, that is perceptible on clinical examination or imaging by 1 year after the index operation. If a visible bulge is made part of the definition, the incidence will be underestimated. In the literature, the incidence of incisional herniation after a midline laparotomy ranges from 3% to 20% and doubles if the index operation was associated with infection.

Herniation is most common after midline and transverse incisions but is also well documented after paramedian, subcostal, appendectomy (gridiron), and Pfannenstiel incisions.<sup>38</sup> A 1995 analysis of 11 publications addressing ventral hernia incidence after various types of incisions found the risk to be 10.5%, 7.5%, and 2.5% for midline, transverse, and paramedian incisions, respectively.<sup>34</sup> Upper midline incisions are most likely to lead to ventral hernia formation; transverse and oblique incisions are the least likely. Muscle-splitting incisions probably are associated with a lower incidence of herniation, but they restrict access to the abdominal cavity. Males and females are at roughly equal risk, but early evisceration is more common in males. Most cases are detected within 1 year of surgery, and the basic cause is thought to be separation of aponeurotic edges in the early postoperative period. Incarceration and strangulation occur with significant frequency, and recurrence rates after operative repair approach 50%.

### Operative Technique

**Simple Nonprosthetic Repair.** Simple nonprosthetic repair of an incisional hernia is reserved for only the least complicated defects, because in large series of unselected patients, the recurrence rate ranges from 25% to 55%.<sup>7</sup> If there is a solitary defect 3 cm or less in diameter, primary closure with nonabsorbable suture material is appropriate. Some surgeons perform a simple edge approximation after flaps are developed on either side of the defect. Others use a Mayo "vest-over-pants" repair. Various advancement and darn procedures have also been described.

A more substantial repair for these defects was popularized by Ramirez.<sup>39</sup> In this operation, known as the component separation technique, fascial planes are incised between muscle groups, so that, in effect, the abdominal wall is lengthened by allowing the muscle to separate on either side of a defect. The hernia can then be repaired primarily with less tension on the repair. This procedure is especially useful at contaminated hernia sites.

A similar procedure is the keel operation of Maingot, which was popular in the middle of the 20th century. The anterior rectus sheath is incised longitudinally, and the medial edge is allowed to rotate behind the rectus abdominis. This, in effect, lengthens the posterior rectus sheath, allowing it to be closed under less tension. The lateral edges of the incised rectus sheath on each side are then approximated to each other.

**Onlay Prosthetic Repair.** In this technique, a prosthetic onlay is placed over any of a wide variety

of simple repairs. Large series of selected patients have documented acceptable results with onlay prosthetic repair, but most surgeons feel that this technique offers little advantage over the simple repair that the prosthesis overlies.<sup>7</sup>

**Prosthetic Bridging Repair.** Prosthetic bridging repair became popular in the 1990s, in keeping with the tension-free concept for inguinal herniorrhaphy. The basic principle underlying this technique is that for a prosthetic repair to be effective, the defect should be bridged. Although this repair is theoretically attractive, it has not been nearly as successful for incisional hernias as for inguinal hernias. The recurrence rate is especially high in obese patients.

When a hernia defect is bridged with a mesh prosthesis, every attempt should be made to isolate the material from the intra-abdominal viscera to prevent erosion and subsequent fistula formation or adhesive bowel obstruction. This can be accomplished by means of a peritoneal flap constructed from the peritoneal sac or omentum. When contact with intra-abdominal organs cannot be avoided, expanded polytetrafluoroethylene (e-PTFE) should be strongly considered for the prosthesis. Most authorities feel that complications are less likely with e-PTFE, though this has not been unequivocally shown to be the case.

**Combined Fascial and Mesh Closure.** The issue of contact between the intra-abdominal viscera and the prosthesis has been further addressed by techniques that combine features of the component separation technique with the tension-free concept. The posterior fascia is closed primarily, but the anterior fascia is allowed to remain open, so that there is no tension at all. The anterior fascia is then bridged with a prosthesis.

**Sublay Prosthetic Repair.** Sublay prosthetic repair, sometimes referred to as the retromuscular approach, is characterized by the placement of a large prosthesis in the space between the abdominal muscles and the peritoneum [see Figure 17 -- omitted][see Video 2 -- omitted]. It was popularized by Velamanta, Stoppa, and Wantz and is particularly suitable for large and multiply recurrent hernias when most of the abdominal wall must be reconstructed.<sup>40-42</sup> It is considered the most effective conventional incisional hernia repair and therefore the one against which other procedures must be measured.

The posterior rectus sheath is opened on each edge of the hernia defect and dissected away from the undersurface of the recti for a distance of 10 to 15 cm. The posterior rectus sheaths are then approximated to each other primarily. A large mesh prosthesis (composed of e-PTFE if the approximation of the posterior rectus sheath is inadequate) is then placed in this space outside the repaired posterior sheath but beneath the recti. The mesh is secured in this position with several sutures that are placed with a suture passer through small stab incisions at the periphery of the prosthesis and tied in the subcutaneous tissue above the fascia. The laparoscopic incisional herniorrhaphy discussed elsewhere [see 5:28 *Laparoscopic Hernia Repair -- omitted*] was designed with the principles of this operation in mind.

### **Complications**

Although prosthesis-related infection is rare with prosthetic inguinal herniorrhaphies, it remains a major problem with prosthetic incisional herniorrhaphies. It occurs in about 5% of repairs and can delay healing for prolonged periods. Risk factors for prosthesis infection include preexisting infection or ulceration of the skin overlying the hernia, obesity, incarcerated or obstructed bowel within the hernia, and perforation of the bowel during hernia repair. Seromas are common, especially when a large prosthesis is required or there has been extensive flap dissection of the subcutaneous layer from the fascia. Untreated seromas commonly become infected secondarily. Suction drains can be useful but are likely to result in prosthesis infection if left in place too long. Strategies for preventing and managing seromas are largely based on empiricism and personal opinion; objective data are virtually nonexistent. It is not always necessary to remove the mesh prosthesis if infection develops. A trial of local wound care after opening the incision and debriding the infected area is warranted. As noted, some authorities believe that e-PTFE is less prone to infection. Nevertheless, once infection is established, e-PTFE prostheses (unlike mesh prostheses) usually have to be removed.

A dilemma arises when a patient has a large incisional hernia and the wound is contaminated either by skin infection or by injury to the bowel during mobilization. In this situation, a nonabsorbable mesh would have a significant chance of becoming infected, and an enterocutaneous fistula could complicate matters further. For these situations, an absorbable mesh made of polyglycolic acid is recommended to prevent evisceration. Granulation tissue forms over the mesh, making skin grafting possible. The mesh itself is absorbed in about 3 weeks, leaving no permanent foreign body to serve as a persistent focus of infection. Unfortunately, however, recurrence of the incisional hernia is inevitable. The biologic prosthesis now being evaluated for inguinal herniorrhaphy has also been employed in this situation, but the results are as yet unknown.

Several other factors might contribute to the poor results of incisional hernia repair, including preexisting comorbid conditions for which the patient underwent the original operation, cancer-related debilitation, morbid obesity, the use of steroids, and chemotherapy.

### **Repair of Other Abdominal Wall Hernias**

#### **Periumbilical Hernia**

**Gastroschisis.** Gastroschisis is seen in fetuses and neonates. The typical presentation is a defect in the abdominal wall to the right of the umbilicus through which the intestines protrude. There is no associated sac. Usually, only the small bowel and the large bowel are eviscerated; however, the stomach, the liver, and the genitourinary system may be involved. Because the bowel is exposed to amniotic fluid, the maternal serum  $\alpha$ -fetoprotein (AFP) level tends to be elevated, and the bowel may become thickened and dilated as a result. Bowel complications (e.g., malrotation and segmental atresia) are present in approximately 15% of cases of gastroschisis; however, other anomalies are uncommon. Gastroschisis occurs sporadically and is not associated with chromosome abnormalities, though some familial occurrences are reported.

After the presence of gastroschisis is confirmed, serial ultrasonographic follow-up is indicated for measurement of fetal growth and evaluation of bowel status. Counseling of a couple expecting a baby with gastroschisis should include assessment of the prognosis, description of the surgical and medical support the newborn is likely to need, and discussion with both the neonatologist and the pediatric surgeon.

**Omphalocele (Exomphalos).** Omphalocele also is seen in fetuses and neonates. In this condition, a midline defect of the abdominal wall results in herniation of the bowel and intra-abdominal contents into the umbilical cord; the coverings of the hernia are therefore the coverings of the umbilical cord. The defect may be categorized according to whether the liver is present in the omphalocele sac. If the liver is present in the sac, the omphalocele is extracorporeal; if not, the omphalocele is intracorporeal. Omphalocele differs from gastroschisis in that the bowel contents are contained in a membrane, and thus, maternal serum AFP levels generally are not elevated. Often, ascites develops within the omphalocele sac.

Amniocentesis is indicated when an omphalocele is identified in a fetus, because approximately 30% of fetuses with an omphalocele have a chromosome abnormality. The most common such abnormalities are trisomies 18, 13, and 21; Turner syndrome (45, X); and triploidy. Beckwith-Wiedemann syndrome may also be associated with omphalocele. Approximately 67% to 88% of fetuses with an omphalocele have other anomalies as well. These associated anomalies often determine the prognosis.

**Umbilical and Paraumbilical Hernia.** An umbilical hernia is the result of improper healing of an umbilical scar, which leads to a fascial defect that is covered by skin. If the defect is to one side, it is called a paraumbilical hernia; this variant is more common in adults. The vast majority of umbilical hernias presenting in children are congenital, whereas 90% of those diagnosed in adults are acquired. These hernias are eight times more common in black children than in white ones. The onset of umbilical or paraumbilical hernia in older patients is usually sudden, and the defect tends to be relatively small. In these patients, it is important to look for an underlying cause of increased intra-abdominal pressure (e.g., ascites or an intra-abdominal tumor).

The differential diagnosis of an umbilical hernia should include so-called caput medusae, a condition in which varicosities extend radially from the umbilicus as a consequence of portal hypertension. These varicosities look like varicose veins, exhibit a bluish discoloration, and fill when the patient strains. Another condition to be considered is the so-called Sister Mary Joseph node, which is a metastatic deposit of intra-abdominal cancer at the umbilicus. The cancer cells reach this area via lymphatic vessels in the falciform ligament. A hard nodule is palpable at the umbilicus, and biopsy verifies its cancerous nature. Other periumbilical masses that might be confused with an umbilical hernia are umbilical granulomas, omphalomesenteric duct remnant cysts, and urachal cysts.

Management of umbilical hernias is conservative in children younger than 2 years. A large proportion of these defects heal spontaneously. Consequently, the usual practice is to observe the hernia until the child has reached 2 years of age, by which point about 80% of defects will have healed. Umbilical hernias persisting after the age of 2 years probably will not heal spontaneously and therefore must be treated surgically. The customary recommendation is to repair the hernia by the time the child reaches 5 years of age, so that he or she is not subjected to psychological trauma when participating in normal school sports activities.

In young patients, compression of the hernia with a bandage or a coin is commonly attempted. This practice probably has no real effect but has gained acceptance by parents; the high rate of spontaneous closure fuels the perception (or misperception) of efficacy. In patients who do require surgery—namely, children older than 2 years and adults—the repair used depends on the size of the hernia. Most of the defects are small and can therefore be closed by simple suturing. Alternatively, the Mayo technique may be used. A subumbilical semilunar incision is made, the hernial sac is opened, the contents of the sac are reduced into the abdomen, and the sac is excised. An overlapping or waistcoating technique is then employed, in which the upper edge of the linea alba is placed so as to overlap the lower and fixed in place with a nonabsorbable mattress suture. This technique is controversial: some surgeons argue that the overlapping layers serve only to increase the tension on the repair, thus inviting recurrence.

For larger hernias, particularly those in adults, a popular approach is to dissect the sac away from the undersurface of the skin of the umbilicus and reduce it into the preperitoneal space. The fascial defect is then bridged with a prosthesis without fear of contact with the intra-abdominal viscera. The prosthesis is sutured circumferentially to the defect; alternatively, it can be sutured to the undersurface of the posterior rectus sheath and the linea alba above the peritoneal closure. If the peritoneum cannot be kept intact beneath the defect, omentum should be tacked to the peritoneum

circumferentially to isolate the abdominal viscera from the prosthesis at least to some degree.

### ***Epigastric Hernia***

Epigastric hernias occur through a defect in the linea alba. In most patients with these hernias, as well as those with umbilical hernias, only a single decussation of the fibers of the linea alba is present, as opposed to the triple decussation seen in most persons; this abnormality is the cause of the defect in the midline.

The reported incidence of epigastric hernia ranges from less than 1% to as high as 5%. They are two to three times more common in men than in women, and 20% of them are multiple. Most defects are less than 1 cm long and contain only incarcerated preperitoneal fat, with no peritoneal sac. For this reason, they generally cannot be visualized laparoscopically. The usual complaint is a painful nodule in the upper midline. As a rule, reduction of the preperitoneal fat and simple closure of the defect resolves the complaint. Given the relatively high recurrence rate (up to 10%), however, some surgeons prefer to place a postage stamp-sized piece of prosthetic material in the preperitoneal space to reinforce the repair. Others bridge the defect by suturing the prosthesis circumferentially. Some authorities recommend exposure of the entire linea alba because of the incidence of multicentricity. We believe that this practice leads to unnecessary morbidity. Instead, we make a small incision with the patient under local anesthesia and explain to him or her that additional repairs may be required later.

Left untreated, an epigastric hernia can become large enough to develop a peritoneal sac into which intra-abdominal contents can protrude. Usually, however, the sac is wide, and serious complications are infrequent.

### ***Diastasis Recti***

In diastasis recti, the two recti abdominis are separated quite widely, and the linea alba area is stretched and protrudes like a fin. Although the protrusion is easily reducible and almost never produces complications, many patients find it unsightly and request treatment. Surgical therapy would involve removing a strip of the weakened linea alba and reapproximating it; however, this approach could result in tension, which in turn might lead to recurrence. The alternative would be a mesh repair.

### ***Parastomal Hernia***

Parastomal hernia is one of the most common complications of stoma formation. Its incidence is much higher than is generally appreciated. There is good evidence to suggest that more than 50% of patients will eventually be found to have a paracolostomy hernia if followed for longer than 5 years.<sup>43</sup> The rate of herniation with small bowel stomas is also discouraging, though less so than that with colostomies. The results of parastomal hernia repair are particularly dismal, with recurrence being the rule rather than the exception.

Some parastomal hernias can be accounted for by poor site selection or technical errors (e.g., making the fascial opening too large or placing a stoma in an incision), but the overall incidence is too high to be explained by these causes alone. Placement of the stoma lateral to the rectus sheath is widely touted as a cause of parastomal hernia, but this claim is not universally accepted. Obesity, malnutrition, advanced age, collagen abnormalities, postoperative sepsis, abdominal distention, constipation, obstructive uropathy, steroid use, and chronic lung disease are also contributing factors.<sup>44,45</sup>

Newer techniques for stomal construction (e.g., extraperitoneal tunneling) have had little impact on the incidence of parastomal hernia. Fortunately, patients tolerate these hernias well, and life-threatening complications (e.g., bowel obstruction or strangulation) are rare. Routine repair, therefore, is not recommended; repair is appropriate only when there is an absolute or relative indication [see *Table 5 -- omitted*]. If repair is considered, patients must be informed that there is a significant chance that the hernia will recur.

Three general types of parastomal hernia repairs are currently performed: (1) fascial repair, (2) stomal relocation, and (3) prosthetic repair. Fascial repair involves local exploration around the stoma site, with primary closure of the defect. This approach should be considered of historical interest only because the results are so miserable. Stomal relocation yields much better results and is considered the procedure of choice by many surgeons. This approach is especially appropriate for patients who have other stomal problems (e.g., skin excoriation or suboptimal stomal construction). The use of a prosthesis with stomal relocation is not generally recommended because of the inherent danger of contamination. In the past few years, the popularity of stomal relocation has waned because of the realization that many patients who undergo this procedure ultimately end up with three hernias instead of one: incisional hernias develop in the old stoma site and the laparotomy incision, while a paracolostomy hernia develops at the new site.

Prosthetic repair appears to be the most promising approach, but it is necessary to accept the complications inherent in the placement of a foreign body. The stomal exit site must be isolated from the surgical field to lower the risk of prosthesis-related infection. The prosthesis can be placed extraperitoneally by making a hockey-stick incision around the stoma, taking care to ensure that the incision is outside the periphery of the stomal appliance. Once the subcutaneous tissue is divided, dissection proceeds along the fascia until the sac is identified and removed. The defect is then

closed and an overlying prosthesis buttress sutured in place. Alternatively, the fascial defect is bridged with the prosthesis for a "tension-free" repair.

The extraperitoneal prosthetic approach seems logical but can be very technically demanding, in that it is sometimes difficult to define the entire extent of the hernia defect. Moreover, the considerable undermining involved can lead to seroma formation and eventual infection. As an alternative, an intra-abdominal prosthetic approach has also been described that is theoretically attractive because it avoids the local complications of the extraperitoneal operation and incorporates the mechanical advantage gained by placing the prosthesis on the peritoneal side of the abdominal wall.<sup>46,47</sup> Intra-abdominal pressure then serves to fuse the prosthetic material to the abdominal wall rather than being a factor in recurrence. Either e-PTFE or polypropylene mesh can be used. The detractors of the intra-abdominal approach argue that the risk of complications (e.g., adhesive bowel obstruction and fistula formation resulting from the intra-abdominal placement of the prosthesis) outweighs the advantages. The intra-abdominal approach is particularly well suited for laparoscopic repair, and several techniques have been described.<sup>48,49</sup>

### **Spigelian Hernia**

The Flemish anatomist Adriaan van der Spiegel was the first to describe the semilunar line, which defines the lower limit of the posterior rectus sheath. A spigelian hernia protrudes through an area of weakness just lateral to the rectus sheath and just below this line.<sup>50</sup> The hernia usually is interparietal and rarely penetrates the external oblique fascia; consequently, it can be difficult to appreciate. Spigelian hernias are unusual, with fewer than 750 cases described in the literature to date; however, given that they are so easily diagnosed laparoscopically, it is possible that the incidence will increase. These hernias tend to occur more often in elderly female patients. It is difficult to explain precisely why spigelian hernias develop; there is no area of weakness in the abdominal wall caused by the passage of blood vessels through the abdominal wall in this position. Undoubtedly, childbirth and various other events that stretch the abdominal wall contribute to their development.

Spigelian hernias are usually small (about 1 to 2 cm in diameter), though large ones (up to 14 cm in diameter) have been described. Omentum, small bowel, or large bowel may enter the sac. Incarceration and strangulation are common complications. The usual clinical presentation is a lower abdominal swelling just lateral to the lateral border of the rectus abdominis. In many cases, however, pain and tenderness are the only signs. Plain x-rays may show a bowel shadow in this area, and of course, CT scanning visualizes the defect and the hernia well.

The standard treatment for a spigelian hernia is operative repair. A transverse incision is centered over the mass. The external oblique aponeurosis is split to reveal the protrusion. If there is a large sac, it is divided and sutured. The aponeurotic defect is triangular, with the base located at or near the lateral border of the rectus abdominis. The defect is closed by joining the separated transversus abdominis and internal oblique muscle layers. Recurrence is uncommon.

### **Supravesical Hernia**

Supravesical hernias develop anterior to the urinary bladder as a consequence of failure of the integrity of the transversus abdominis and the transversalis fascia, both of which insert into Cooper's ligament.<sup>51</sup> The preperitoneal space is continuous with the retropubic space of Retzius, and the hernial sac protrudes into this area. The sac is directed laterally and emerges at the lateral border of the rectus abdominis in the inguinal region, the femoral region, or the obturator region. It also may be associated with an inguinal hernia, a femoral hernia, or an obturator hernia. Treatment of a supravesical hernia involves prompt recognition of the defect at the time of groin exploration and appropriate reinforcement of the area of the defect.

A variant of this hernia, known as an internal supravesical hernia, may also arise. Internal supravesical hernias are classified according to whether they cross in front of, beside, or behind the bladder. Bowel symptoms predominate in patients with these defects, and urinary tract symptoms develop in as many as 30%. Treatment is surgical and is accomplished transperitoneally via a low midline incision. The sac can usually be reduced without difficulty; the neck of the sac should be divided and closed.

### **Interparietal Hernia**

With an interparietal hernia, the hernial sac lies between the layers of the abdominal wall. It may be either preperitoneal (between the peritoneum and the transversalis fascia) or interstitial (between the muscle layers of the abdominal wall). Most interparietal hernias are of the latter type and occur in the groin; accordingly, they are designated inguinal interstitial hernias. When the sac passes behind the inguinal ligament in the region of the femoral ring, the resulting defect is known as an inguino-crural hernia.

The cause of interparietal hernias appears to be related to congenital abnormalities (e.g., maldescent of the testis, congenital pouches, absence of the cremaster muscle, and absence of the external abdominal ring). Diagnosis is difficult because there is no obvious swelling of the abdominal wall unless the hernia is large. In many cases, pain is the only symptom; therefore, it is not unusual for patients to present with intestinal obstruction secondary to incarceration. CT, ultrasonography, and laparoscopy can facilitate the diagnosis. Not infrequently, the correct

diagnosis is made only at operation. Treatment starts by addressing the intestinal obstruction that is so often the presenting symptom. The defect itself is then repaired in accordance with the same principles followed in inguinal or incisional herniorrhaphy.

### **Richter's Hernia**

In a Richter's hernia, part of the bowel wall herniates through the defect and may become ischemic and gangrenous, but intestinal obstruction does not occur. The overlying skin may be discolored. The herniated bowel wall is exposed by opening the sac, and the neck of the sac is enlarged to allow delivery of the bowel into the wound. The gangrenous patch is excised and the bowel wall reconstituted. The hernia is then repaired.

### **Lumbar Hernia**

The lumbar region is the area bounded inferiorly by the iliac crest, superiorly by the 12th rib, posteriorly by the erector spinae group of muscles, and anteriorly by the posterior border of the external oblique muscle as it extends from the 12th rib to the iliac crest. There are three varieties of lumbar hernia:

1. The superior lumbar hernia of Grynfelt. In this variety, the defect is in a space between the latissimus dorsi, the serratus posterior inferior, and the posterior border of the internal oblique muscle.
2. The inferior lumbar hernia of Petit. Here, the defect is in the space bounded by the latissimus dorsi posteriorly, the iliac crest inferiorly, and the posterior border of the external oblique muscle anteriorly.
3. Secondary lumbar hernia. This hernia develops as a result of trauma—mostly surgical (e.g., renal surgery)—or infection. In the past, it was encountered relatively frequently as a consequence of spinal tuberculosis with paraspinal abscesses; however, it is less common today. Surgical repair is discouraged because the natural history is more consistent with that of a diastasis recti than that of a true hernia. Denervation appears to play a significant role in the pathogenesis. In other words, this “hernia” really reflects a weakness in the abdominal wall more than it does a dangerous hernia defect. Therefore, appropriate repair is commonly followed by gradual eventration, which is perceived by the patient as a recurrence.

Lumbar hernias should be repaired if they are large or symptomatic. A prosthesis or a tissue flap of some kind is usually required for a successful repair. A rotation flap of fascia lata can be used for inferior lumbar hernias.

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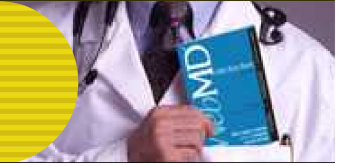
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