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Groin Hernia Repair: Open Techniques

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Abstract. Since the introduction of the Bassini method in 1887, more than 70 types of pure tissue repair have been reported in the surgical literature. An unacceptable recurrence rate and prolonged postoperative pain and recovery time after tissue repair along with our understanding of the metabolic origin of inguinal hernias led to the concept of tension-free hernioplasty with mesh. Currently, the main categories of inguinal hernia repair are the open repairs and the laparoscopic repairs. In the open category, repair of the hernia is achieved by pure tissue approximation or by tension-free mesh repair. The most commonly performed tissue repairs are those of Bassini, Shouldice, and to a lesser extent McVay. In the tension-free mesh repair category, the mesh is placed in front of the transversalis fascia, such as with the Lichtenstein tension-free hernioplasty, or behind the transversalis fascia in the preperitoneal space, such as during the Nyhus, Rives, Read, Stoppa, Wantz, and Kugel procedures. Numerous comparative randomized trials have clearly demonstrated the superiority of the tension-free mesh repair over the traditional tissue approximation method. Placing mesh behind the transversalis fascia, although a sound concept, requires extensive dissection in the highly complex preperitoneal space and can lead to injury of the pelvic structures, major hematoma formation, or both. In addition, according to the prospective randomized comparative study of mesh placement in front of versus behind the transversalis fascia, the latter offers no advantage over the former, and it is more difficult to perform, learn, and teach. More importantly, preperitoneal mesh implantation (via open and laparoscopic procedure) leads to obliteration of the spaces of Retzius and Bogros, making certain vascular and urologic procedures, in particular radical prostatectomy and lymph node dissection, extremely difficult if not impossible. In conclusion, according to level A evidence from randomized comparative studies, (1) mesh repair is superior to pure tissue approximation repairs, and (2) mesh implantation in front of the transversalis fascia is superior, safer, and easier than open or laparoscopic mesh implantation behind the transversalis fascia.

Formulation of the Bassini method in 1887 brought about a greater understanding of inguinal hernias and the first attempt at a "cure." For more than 50 years the true Bassini repair (opening the posterior wall of the inguinal floor, "the transversalis fascia") was used in Europe and the so-called corrupted Bassini repair (imbrication of the transversalis fascia without opening the inguinal floor) in North America. However, the high recurrence rate in the hands of surgeons at large following the Bassini repair led to transition to the Shouldice procedure during the early 1950s.

The next major movement in herniology was the use of prosthetic materials, a concept envisioned by Billroth in 1878 and partially realized by the advent of silver filigree, tantalum mesh, and a variety of plastic meshes. However, it was not until the late 1950s and early 1960s, when Francis C. Usher introduced polyethylene (later replaced by polypropylene), that the radical cure of inguinal hernias, as envisioned by Billroth, became a reality.

Two important revelations followed: Rives, Stoppa, Read, and the Aachen group recognized the metabolic origin of inguinal hernias and the role of impaired collagen metabolism in the pathogenesis of groin hernia (altered collagen type I/type III ratio) [1, 2], and Irving Lichtenstein underscored the adverse effect of suture line tension. These new discoveries led to widespread use of polypropylene mesh for repairing inguinal hernias. During the early 1990s, the laparoscopic method of mesh implantation in the preperitoneal space was used. Currently, the main categories of inguinal hernia repair are pure tissue repair and open and laparoscopic tension-free repairs with mesh.

Materials and Methods

As summarized in Table 1, the current methods of open hernia repair can be categorized as: (1) tissue approximation repair (Bassini, Shouldice, McVay) and (2) open tension-free prosthetic repair, in which mesh is placed in front of the transversalis fascia (Lichtenstein open tension-free hernioplasty) or behind it (Nyhus/Condon, Rives, Read, Stoppa, Wantz, and Kugel procedures).

Tissue Approximation Repairs

More than 70 types of tissue repair have been reported in the surgical literature. The techniques still in use are those of Bassini, Shouldice, and to a lesser extent McVey. Because of the high recurrence rate following the Bassini repair, the Shouldice repair is preferred. Advocates of the procedures claim that the recurrence rates reported by the pioneers of the Bassini and Shouldice repairs are reproducible by surgeons, at large. However, according to a major European study by Beets et al. [3], the reported

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Table 1. Current Methods of open hernia repair.

Tissue approximation repairs (e.g., Bassini, Shouldice, McVey)
Open Tension-free repairs
Mesh placement in front of the transversalis fascia (Lichtenstein technique)
Mesh placement behind the transversalis fascia (Nyhus, Rives, Stoppa, Read, Wants, and Kugel procedures)

recurrence rate in nonspecialized centers following pure tissue repair is as high as 35%. This is because all such repairs require approximation of already degenerated and compromised anatomic structures that are not normally in apposition. Consequently, there is undue tension at the suture line, which in turn leads to an unacceptable recurrence rate, postoperative discomfort, and prolonged recovery. The ongoing degeneration of the approximated tissue also leads to late recurrences. Numerous randomized comparative trials have clearly demonstrated the superiority of tension-free mesh repair over the traditional tissue approximation methods [4–6].

Open Tension-Free Mesh Repairs

Unacceptable recurrence rates and prolonged postoperative pain and recovery time following pure tissue repairs brought about the concept of prosthetic tension-free hernioplasty (a term coined by the Lichtenstein group). Numerous prosthetic materials were developed as a result, but many produced disastrous complications related to rejection and infection. Usher is credited with popularizing the use of polypropylene mesh, which has been in use for nearly 50 years with a negligible complication rate. In 1989, Nyhus abated the fear of infection and rejection when he stated," My concerns relative to the potentially increased incidence of infection or rejection of polypropylene mesh have not been warranted to date [7]. Choosing the proper biomaterial, therefore, can determine the success of an operation and prevent biomaterial-related complications. In-depth knowledge and understanding of the physical properties of the prosthesis, porosity, and pore size in particular are required. Classification of biomaterials for hernia surgery is essential for everyday practical use of prostheses [8]. The most frequently used prosthetic materials for hernia surgery can be grouped into absorbable and nonabsorbable materials.

As summarized in Table 2, absorbable materials can be divided into synthetic materials (e.g., Dexon and Vicryl) and biologic materials (e.g., acellular dermis, porcine dermal collagen, and porcine small intestinal submucosa). The latter group has much greater longevity than the synthetic ones. All absorbable biomaterials are totally replaced by the host tissue; however, there is no scientific evidence that the new tissue has the integrity of normal collagen or the normal type I/type III collagen ratio to withstand the intraabdominal pressure and thus avoid future recurrence. Therefore the only possible recommended use of absorbable materials (synthetic or biologic) is for repairing a hernia in a contaminated setting, where nonabsorbable materials would present an unacceptable risk of chronic infection.

Nonabsorbable materials can be grouped into four types (Table 2).

Type I: Totally Macroporous. The totally macroporous prostheses, such as Atrium, Bard mesh, Prolene, Monofilamented Surgipro, and Trilex, have pores larger than 75 μm, which is

Table 2. Classification of currently available biomaterials for abdominal wall hernia repair.

Absorbable material
Synthetic (e.g., Vicryl, Dexon)
Biologic (e.g., acellular dermis, porcine dermal collagen, porcine small intestine submucosa)
Nonabsorbable material
Type I (e.g., Atrium, Bard mesh, Prolene, Monofilamented Surgipro, Trilex)
Type II (e.g., expanded polytetrafluoroethylene (ePTFE) soft tissue patch, Dual Mesh)
Type III (e.g., ePTFE mesh (Teflon), braided Dacron mesh (Mersilene), braided polypropylene mesh, perforated ePTFE patch (Micromesh))
Type IV (e.g., Silastic, polypropylene film, Preclude Pericordial membrane, Dura Substitute)

required for easy passage of fibroblasts (fibroplasia), collagen fibers, blood vessels (angiogenesis), and macrophages—all essential elements of a strong repair with minimum complications [8].

Type II: Totally Microporous. Examples of the totally microporous prostheses are the expanded polytetraethylene (ePTFE) soft tissue patch and Dual mesh. These protheses have pores of less than 10 μm in at least one of three dimensions. By admitting bacteria but not macrophages, these prostheses harbor and promote infection. In addition, because of their microporosity, they do not provide sufficient tissue incorporation for a strong repair.

Type III: Macroporous with Multifilamentous or Microporous component. The type III group (ePTFE mesh) (Teflon), braided Dacron mesh (Mersilene and Parietex), braided polypropylene mesh (multifilamented Surgipro), and perforated EPTFE (Micro mesh), is associated with sufficient fibroplasia and angiogenesis. However, because of their microporous component, these meshes, are liable to harbor and promote infection.

Type IV: Biomaterials with Submicrometer Pore Size. Examples of type IV materials Silastic, polypropylene film, Preclude Pericordial membrane, and Dura Substitute. They are not suitable for hernia repair; however, in combination with type I biomaterial, they can provide a suitable composite for intraperitoneal implantation without the risk of a biomaterial-related intestinal fistula [9–12].

Currently, the most frequently recommended type of biomaterial for open and laparoscopic inguinal hernia repairs is the totally macroporous monofilament polypropylene meshes (type I). To achieve a tension-free repair, the mesh is implanted in front of or behind the transversalis fascia in the preperitoneal space via either the open or laparoscopic approach.

Lichtenstein Tension-free Hernioplasty

The open tension-free hernioplasty was pioneered by the Lichtenstein group in 1984. The procedure was refined between 1984 and 1989 and reported in the literature [13]. The refined procedure is considered the gold standard for hernia repair by the American College of Surgeons [14]. As frequently is the case, the root of most new developments in surgery can be traced back to the old. During the late 1990 s, it was brought to my attention (by

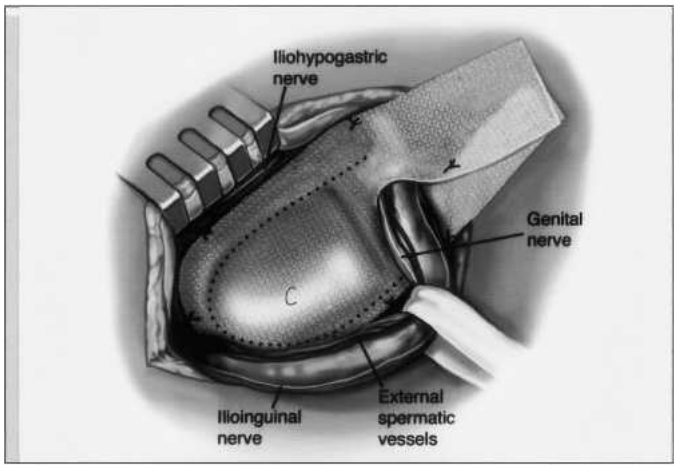

Fig. 1. Extension of the mesh beyond the boundary of the inguinal floor (dotted line) and central laxity of the mesh (approximately 10 mm, marked "C").

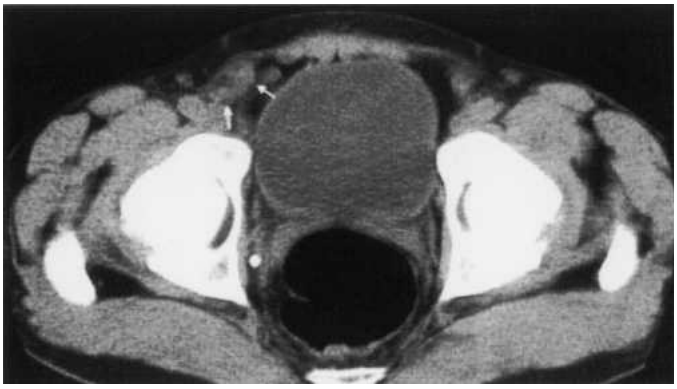

Fig. 2. Computed tomography (CT) scan of a meshoma formed by wrinkling of the deep layer of a bilayerPHS (Prolene Hernia System)hernia device.

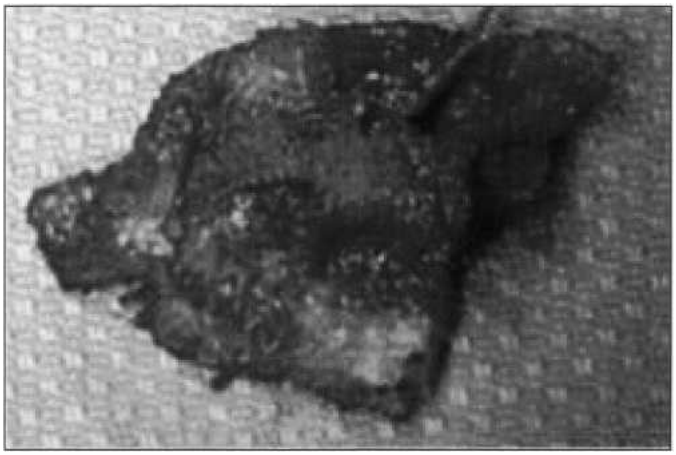

Fig. 3. Explanted specimen corresponding to Figure 2.

the renowned French herniologist Jean-Bernard Flament) that a method of hernia repair similar to the Lichtenstein repair had been described by Zagdoun during the 1940 s. According to more than 200 reports, the most recent of which is the Kingsnorth et al. report, when the key principles of the repair are addressed the rates of recurrence and complication, including chronic pain, are less than 1% [15].

There are five key elements of the Lichtenstein tension-free hernioplasty [16] based on (1) the physiodynamic characteristics of the abdominal wall and intraabdominal pressure gradient, which rises from 8 cm H_2O with the subject supine to more than 80 cm H_2O upon physical exertion (e.g., straining and vomiting) [17], resulting in forward protrusion of the transversalis fascia; and (2) shrinkage of the mesh in vivo, which according to our laboratory and clinical studies (reported during the 1995 Annual Meeting of the American College of Surgeons and published in 1997 [8]) and confirmed by other investigators [18] is approximately 20%.

1. Use a large sheet of mesh (3 × 6 inches, standard shape, resembling the tracing of a footprint) that extends, approximately 2 cm medially beyond the pubic tubercle, 3 to 4 cm above the Hesselbach's triangle, and 5 to 6 cm lateral to the internal ring (Fig. 1).
2. Cross the tails of the mesh behind the spermatic cord to avoid recurrence lateral to the internal ring (Fig. 1).
3. Secure the upper edge of the mesh to the rectus sheath and internal oblique aponeurosis with two interrupted sutures and the lower edge of the mesh to the inguinal ligament with one continuous suture to prevent folding and movement of the mesh in the mobile area of the groin (Fig. 1). Nonfixation or inadequate mesh fixation results in folding and wadding of the mesh (meshoma) [19] (Figs. 2, 3), which can cause chronic pain and recurrence of the hernia.
4. Keep the mesh in a slightly relaxed, tented up, or sagitated configuration [13] (Figs. 1–4) to counteract the forward protrusion of the transversalis fascia when the patient stands up and, more importantly, to compensate for contraction of the mesh.
5. Visualize and protect the ilioinguinal, iliohypogastric, and genital nerves throughout the operation [20] (Fig. 5). The iliohypogastric nerve can be identified easily during separation of the external oblique aponeurosis from the internal oblique layer to make room for the mesh. Because of a natural anatomic cleavage, separation of these two layers from each other is easy, fast, and bloodless. The most vulnerable part of the iliohypogastric nerve is its intramuscular segment, which runs along the lower edge of the internal oblique muscle [20] (Fig. 5). Passing a suture through the internal oblique muscle (the so-called conjoint tendon) to approximate this layer to the inguinal ligament (during tissue approximation repairs) to a plug (during mesh plug repair), or to the upper edge of the mesh (during Lichtenstein repair) is liable to injure the intramuscular portion of the iliohypogastric nerve with the needle or entrap the nerve with the suture. The genital nerve is protected by not removing the cremasteric sheet and keeping the easily visible blue external spermatic vein (the blue line) [20] en bloc with the spermatic cord when it is being lifted from the inguinal floor (Figs. 1, 5). The ilioinguinal nerve can be easily located as it passes over the spermatic cord. Manipulating and lifting the nerve from its natural bed increases the risk of perineural fibrosis and chronic postherniorrhaphy inguinodynia [20].

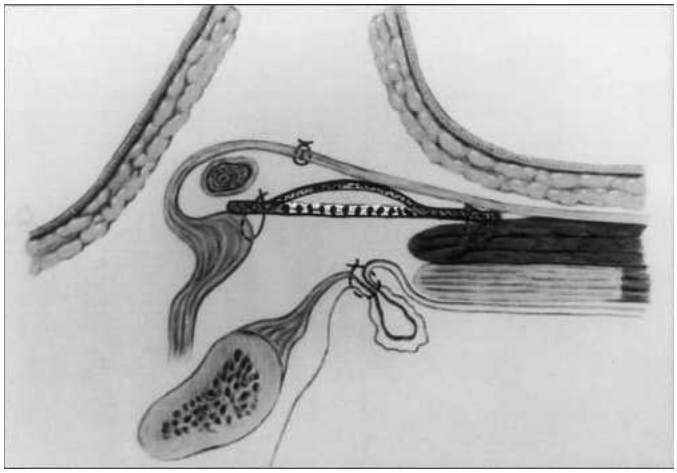

Fig. 4. Cross section of tension-free repair demonstrating an inverted direct hernia sac and laxity of the mesh versus a completely flat mesh (dotted line).

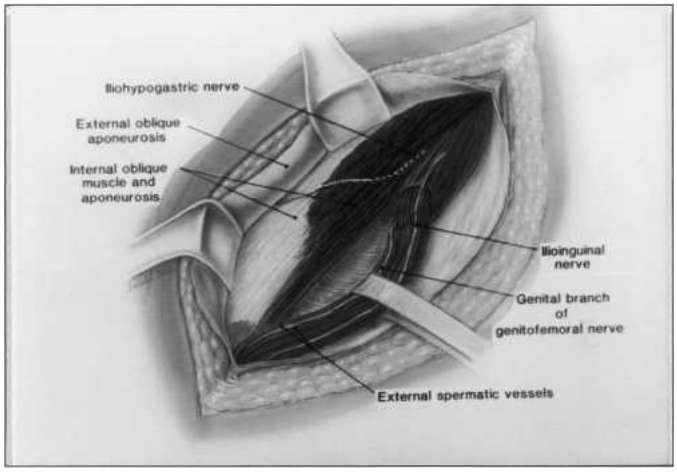

Fig. 5. Anatomy of the periinguinal nerves.

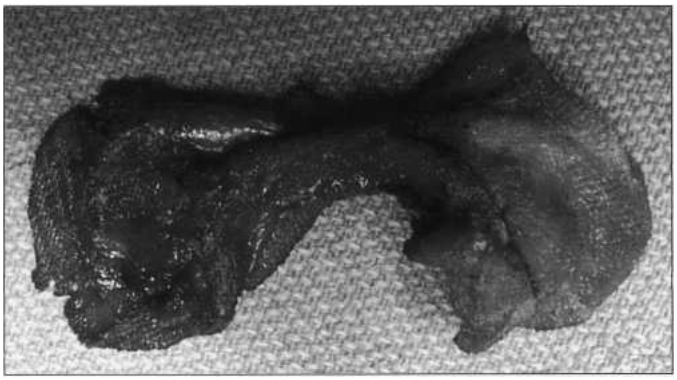

Fig. 6. Explanted twisted and kinked Kugel patch caused by insufficient dissection to accommodate the patch in a flat position.

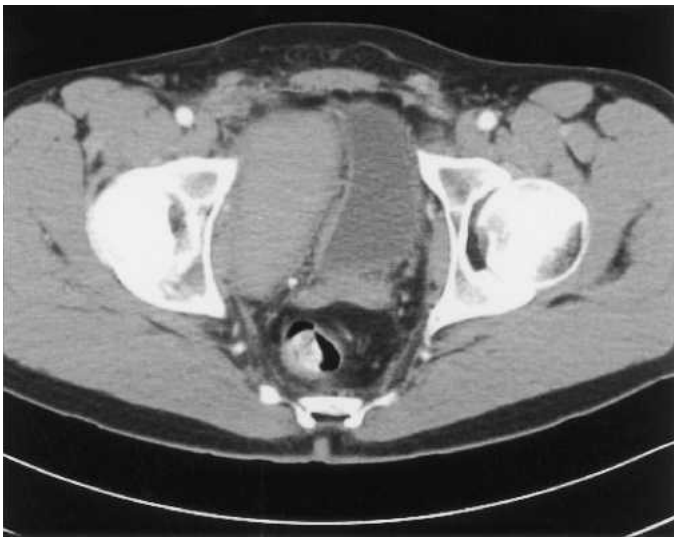

Fig. 7. Large hematoma compresses the bladder after inguinal hernia repair with bilayer hernia mesh.

Mesh Plug Repair

The concept of mesh plug repair was originally described by Lichtenstein in 1974 for the repair of femoral hernias and selected cases of recurrent inguinal hernias [21]. The idea was modified by Gilbert [22] and expanded to include the repair of primary indirect inguinal hernias with an added small sheet of flat mesh placed over the inguinal floor and further expanded to include primary direct inguinal hernias by Rutkow and Robbins [23]. Because of such complications as chronic pain requiring explantation of the plug in approximately 6% of cases [24], scrotal and pelvic migration of the plug [25, 26], and erosion of the plug into the intestine [27] and bladder [8], we stopped using mesh plug repair during the mid-1990s.

Open Preperitoneal Repair

Implantation of mesh behind the transversalis fascia via an open approach can be achieved through (1) a transinguinal method such as the Rives operation; (2) a slit made in the broad abdominal muscles (e.g., the Wantz and Kugel repairs); or (3) a lower midline abdominal incision (e.g., the Stoppa GPRVS method). Although a sound concept, mesh placement behind the transversalis fascia in the preperitoneal space via the open or laparoscopic approach requires unnecessary dissection of this highly complex anatomic space and can lead to injury of pelvic structures such as major blood vessels, bowel, and the bladder. In addition, according to a prospective randomized comparative trial [28], the outcome and recurrence rate of mesh implantation in front of the transversalis fascia versus behind the transversalis are the same. However, placing mesh in front of the transversalis fascia is easier to perform and to learn and teach [28]. During the Kugel operation, adequate dissection to allow enough room to accommodate the patch in a completely flat position is extremely important. Inadequate dissection can lead to folding of the mesh, which can result in a sharp kink in the expanding ring of the patch that may erode through the transversalis fascia into the inguinal canal and cause chronic postherniorrhaphy inguinodynia (Fig. 6). Regardless of the technique or approach, mesh placement behind

the transversalis fascia in the preperitoneal space (spaces of Retzius and Bogros), as described earlier, has led to growing concern among urologists and vascular surgeons, as explained under Discussion.

Combined Mesh Implantation in Front of and Behind the Transversalis Fascia

The Prolene hernia system (PHS) is a bilayer mesh that combines the Lichtenstein repair and the preperitoneal repair. The system comprises two layers: a superficial layer for placement in front of the transversalis fascia and a deep layer for placement behind the transversalis fascia. Blind dissection (by finger or sponge) of the preperitoneal space to create the pocket for the deep layer of the mesh is required. Blind dissection of this highly vascular preperitoneal space, however, can lead to bleeding and hematoma formation (Fig. 7). Furthermore, because the deep layer of the device is not fixed in place, it is prone to folding, wrinkling, and meshonna formation (Figs. 2, 3).

Discussion

Based on prospective randomized comparative studies (level A evidence) open tension-free hernioplasty with mesh is superior to the Bassini and Shouldice methods [4–6]. Placing mesh in the preperitoneal space through an open approach offers no advantage over placing it in front of the transversalis fascia; moreover, it is more difficult to perform, learn, and teach [28].

According to the recent VA Cooperative Studies, Co-sponsored by the American College of Surgeons, which compared laparoscopic repair with the Lichtenstein open tension-free repair, the open procedure is superior to the laparoscopic repair [29]. In addition, the study demonstrated that the laparoscopic approach (totally extraperitoneal, transabdominal preperitoneal) results in a higher recurrence rate and was associated with operative mortality (an issue virtually unheard of with the open hernia repair), the insignificant advantage of only 1 day faster return to normal physical activities, and questionably less pain for 8 days [29].

Before laparoscopic inguinal hernia repair was pioneered during the early 1990s, mesh implantation in the preperitoneal space was limited to repair of recurrent inguinal hernias in the hands of a limited number of hernia experts. Since laparoscopic inguinal hernia repair was introduced, more attention has been focused on using the preperitoneal space for mesh placement during the open or laparoscopic repair of both primary and recurrent inguinal hernias. As a result, many surgical procedures (i.e., Stoppa, Wantz, Kugel, Ugahary) and devices (i.e., Kugel hernia patch, WINGS mesh, 3D Max mesh, Fold mesh, Anatomic mesh, Obtura mesh, Endoroll, Prolene Hernia System) have been marketed; and more procedures and devices will likely be introduced. As the number of preperitoneal inguinal hernia repair increases, there is a growing concern among vascular surgeons and urologists about the extreme risk and difficulty, if not impossibility, of performing urologic and vascular operations—in particular, radical prostatectomy and lymph node dissection—subsequent to open and laparoscopic preperitoneal hernia repair [30–38]. These problems, however, may be prevented by using the same protective measures taken to prevent the adherence of mesh to the intestine during intraabdominal mesh implantation (via open and laparoscopic approaches) for the repair of ventral hernias using composites (e.g., Cornposix, Composix EX) made up of a layer of polypropylene mesh for complete tissue incorporation coupled with a layer of nonabsorbable tissue-impervious laminar membrane to protect the intestines from the mesh [9–12]. Similarly, these composites can be used for preperitoneal inguinal hernia repair (open or laparoscopic) to protect the iliac vessels and prostate area with a protective membrane facing the iliac vessels and prostate.

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