ANTONIO GUARNIERI

INGUINAL HERNIA and PHYSIOLOGICAL HERNIOPLASTY

CENTRO STUDI CLINICA GUARNIERI
ROME 1999

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INTRODUCTION

Widespread and easily tolerated, the inguinal hernia is seen as a minor disorder. Because hernia surgery may be performed easily and successfully in both in- and out-patient environments it is too often dismissed as a trivial complaint. On the other hand, in many countries it is considered a specialization.
Unless inguinal hernia is treated properly, in fact, it may turn out to be very disabling. Furthermore, international statistics show that recurrences exceed the 10% mark. This means high social costs. In Italy the number of hernia operations per annum stands around 100,000. Recurrent hernia surgery presents a higher relapse risk rate than primary surgery. Repeated operations may also represent a hazard for the testicular vessels.
The fact that the solution to the problem is by no means straightforward is reflected in the existence of about 80 techniques, of which over 20 currently in use.
Modern hernia surgery came to the fore in Italy in 1884 with Edoardo Bassini. His technique, based on the reconstruction of normal anatomical conditions, is one of the most frequently performed techniques in use even today, perhaps because it is easy to carry out despite its limits. It eliminates the physiological mechanisms that defend the inguinal region from the stress of endoabdominal pressure and creates a cicatricial barrier. However, in large hernias, excess suture traction remains and the risk of recurrence is high.
Prosthetic surgery. Since the end of the 1950's, biocompatible meshes have provided hernia surgery with noteworthy advantages. The primary benefit of prosthetic surgery is that weak tissue is replaced and suture tension eliminated. Although many surgeons advocate the employment of prosthetic

meshes, they have not yet been universally accepted. Effectively speaking, the use of foreign bodies, that is, meshes in all hernias does appear too much of an exaggeration.
Physiological hernioplasty is the name I have given to the technique I outline here. At the end of the 1980's, having used various techniques, with and without mesh, I grew dissatisfied with the cicatricial barrier produced by traditional techniques and with overuse of prostheses. So, I began to seek a new solution.
My primary goal was *to reconstruct the physiology* by reactivating the inguinal region□s muscular defense mechanisms. The inguinal region is a notoriously weak area because it is crossed by the tunnel containing the spermatic cord running through prevalently fascial tissue. On the contrary, where muscle tissue exists, there is no hernia because this tissue contracts and hardens when endoabdominal pressure increases. In hernia patients the muscles of the inguinal region are nearly always hypotrophic and the inguinal canal altered. I thought of the possibility *of modifying the anatomic structure of the inguinal region so that it might be adapted to the needs of physiology*. It was clear to me that any attempt at repairing the deep ring would be a failure because the tissue surrounding it is particularly weak in hernia patients. Therefore, I thought of closing the ring completely and creating a totally new one at the same anatomic level, but more medial than the original and in a stronger area. At the same time, it occurred to me that the external oblique aponeurosis might be exploited as an extraordinarily efficacious biological "prosthesis" to reinforce the non-muscle zones and modify the dimensions of the inguinal canal which could then be adjusted to the muscular-tissue. In December 1988 I began to make use of this method. Since then, we have operated on over 2,000 inguinal hernia patients.
The results have been successful. The incidence of recurrence stands at about 0.7% for primary hernias and most of the operations have been performed in local anesthesia. The meshes used as reinforcement in primary hernias, were availed of only in the presence of very poor tissues, that is, about 5% of the total for the experienced surgeon.
All the research and clinical work has been carried out in two private hospital departments: the CLINICA GUARNIERI and ARS MEDICA in Rome. This is rather unusual for Italy where most research is carried out in public hospitals and in university clinics.
I wish to thank all my collaborators: doctors, technicians, and my team of nurses, clerks and assistants. They are all wonderful people indeed.
This book is not a new edition of my previous "*La nuova chirurgia dell'ernia*" (Masson 1995) but rather a condensed and updated version of it.
It is intended for the surgeons of today but above all for those of tomorrow, who, maybe when enthusiasm for prostheses dies down and old methods grow even older, will judge my proposal with greater serenity and equilibrium.

Rome, August 1999

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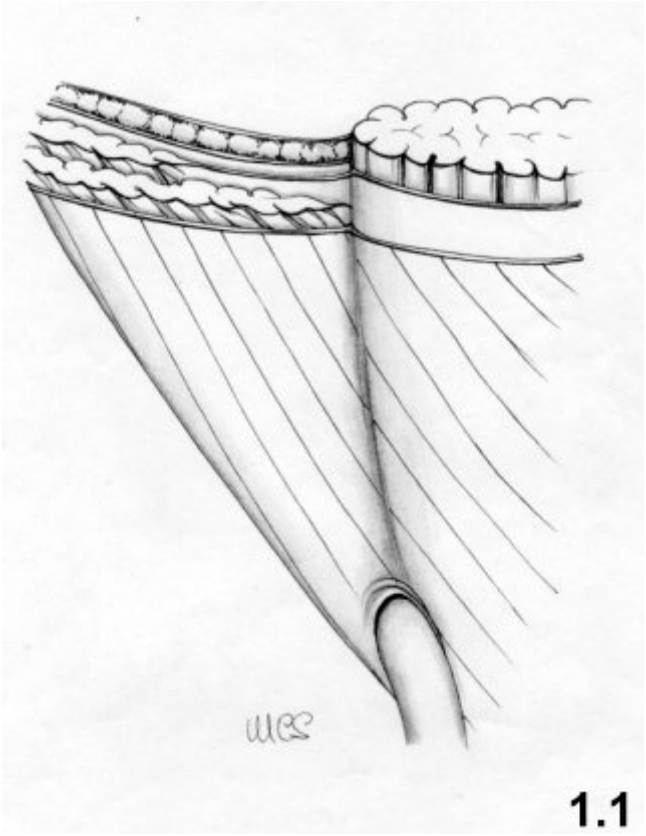
Part One - Current Techniques

1 SURGICAL ANATOMY NOTES

The external oblique aponeurosis (Fig. 1.1)

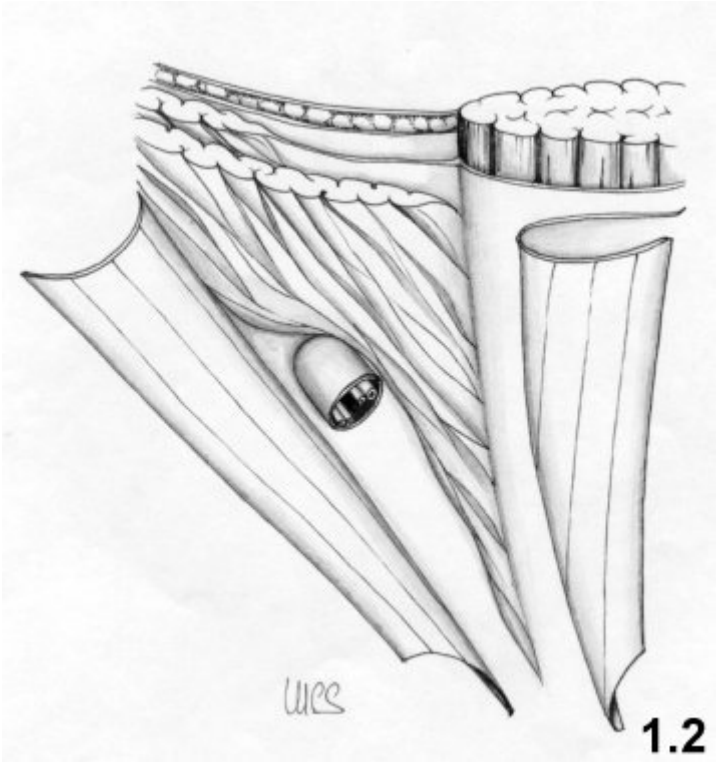


The external oblique aponeurosis is the front wall of the inguinal canal and, at its lateral and lower location, is the continuum of the inguinal ligament. The superficial inguinal ring is the passage through which the spermatic cord passes and is covered by a thin membrane - the external spermatic fascia. The external oblique aponeurosis is joined medially to the aponeurosis of the internal oblique and transversus muscles, forming the medial half of the anterior rectus sheath (Fig. 1.3). The lateral half of the rectus sheath is simply covered by the external oblique aponeurosis, from which it may be separated with greater or lesser ease.
Contraction of the external oblique muscle stiffens the aponeurosis and causes a narrowing of the superficial ring.

The cribriform fascia

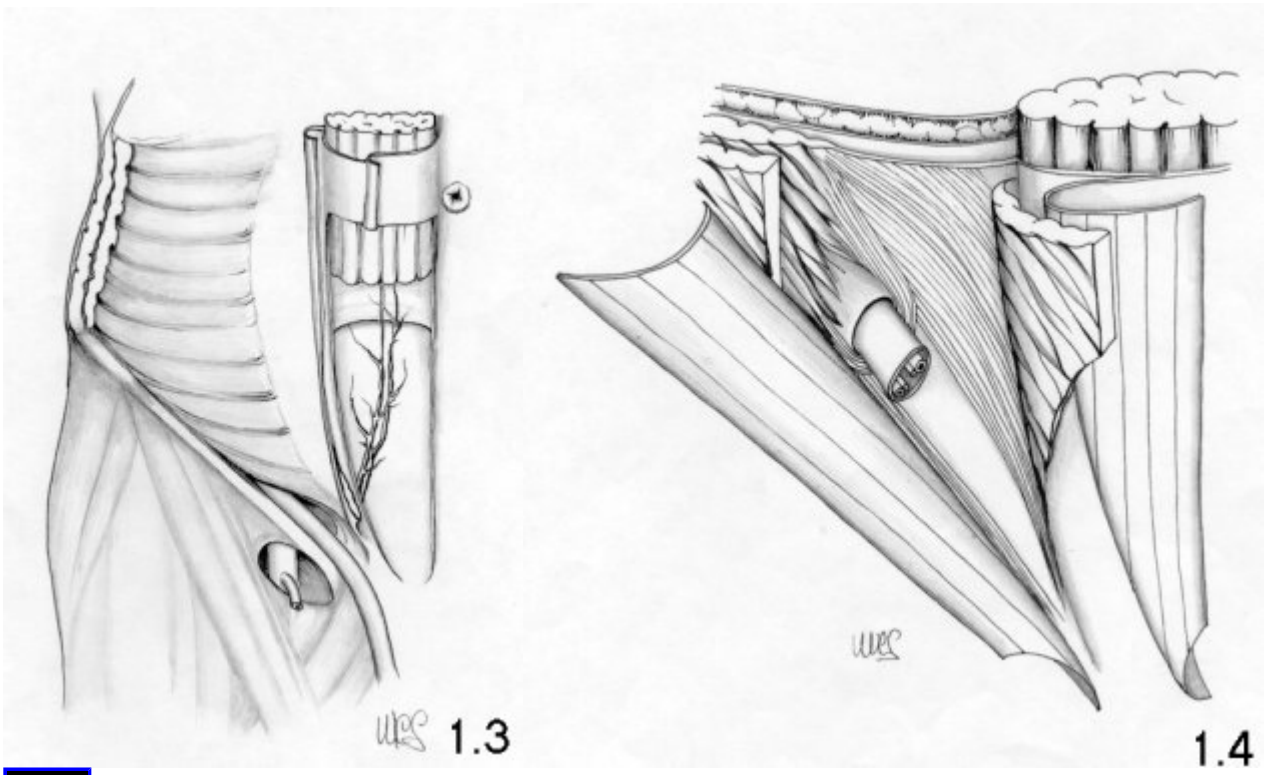
This is a thin layer that occludes the *fossa ovalis*. It is the continuation of the *femoralis fascia* and is joined to the external oblique aponeurosis. It covers the femoral canal from which it is separated by lax fatty tissue.

The internal oblique muscle (Fig. 1.2)



Below the external oblique aponeurosis lies a lower layer. Medially, it consists of the lateral side of the rectus sheath; originating from the fusion of the aponeurosis of the internal oblique muscle and the transversus muscle. Continuing laterally we find the internal oblique muscle which usually borders on the rectus sheath and sometimes covers it completely.
Only the inferior part of the internal oblique muscle is a part of the inguinal region. It covers the transversus muscle and its aponeurosis. The lower fibers of the internal oblique muscle form an arch that circumscribes the funiculus along the inguinal canal. The inferior border of the internal oblique muscle normally reaches the pubic spine. In hernia patients, the insertion of the inferior edge of the internal oblique muscle often reaches the rectus sheath in a position rather high compared to the pubic spine. The result is a triangular zone surrounded by the inferior border of the internal oblique muscle, by the inguinal ligament and by the lateral border of the rectus sheath. Thus, this area, called the *inguinal triangle* (see Fig. 6.3), is not defended by the internal oblique muscle, which gives rise to a tendency to yield and produce direct hernias. The *inguinal triangle must not be confused with the Hesselbach triangle* which is surrounded by the inguinal ligament, inferior epigastric vessels and the lateral border of the rectus muscle.

The transversus muscle (Fig. 1.3 - 1.4)



The transversus muscle follows the same path as the internal oblique muscle, is located deeper and is less present in the inguinal region than the latter. The inferior edge of the muscular part does not, in most cases, reach the midpoint of the inguinal ligament. In 26% of all cases does not go beyond the anterior superior iliac spine. Medially too this muscular portion ends at a certain distance from the rectus muscle. The transversus muscle at inguinal canal level is scarcely represented.

The aponeurosis of the transversus muscle and transversalis fascia The deep inguinal ring (Fig 1.4)

The anterior aponeurosis of the transversus muscle and the transversalis fascia are practically joined together and represent the posterior plane of the inguinal region. To be exact, the aponeurosis of the transversus forms an arch, called the *aponeurotic arch of the transversus*, which coincides substantially with the arch of the internal oblique muscle. Therefore, the posterior wall of the canal, behind the funiculus, consists of a layer, the transversalis fascia, which is reinforced laterally by the iliopubic tract and medially by the aponeurotic arch of the transversus. The aponeurotic arch of the transversus should not be confused with the semilunar line of Spigelio (Fig 1.3) that is, the border between the muscular and the aponeurotic part of the transversus which runs from the hypochondrium to the inguinal region. Cranially and laterally, the deep ring is bordered on by the trasversalis fascia and transversus muscle or by its aponeurosis. Medially and caudally, it borders on the plane comprising the aponeurosis of the transversus + transversalis fascia, which in this tract presents a sling-shaped thickening. The two ends of this thickening are called, respectively, inferior and superior crura. The inferior crus is the shorter of the two, is positioned laterally, joining the iliopubic tract. The superior crus, which is longer, is directed upwards, laterally and backwards, forming a flap on the trasversalis fascia to the inner side of the deep ring.
Medially, the aponeurosis of the transversus muscle joins the aponeurosis of the internal oblique muscle to form the anterior part of the rectus sheath while the trasversalis fascia passes behind the rectus muscle. Laterally, along the angle of the transversalis fascia and the inguinal ligament there is a thickening, the *iliopubic tract*. At a deeper level, the transversalis fascia joins the femoral vessels and the Cooper ligament, and forms the femoral septum that occludes the crural ring.

The contraction of the transversus muscle attracts the superior crus upwards and laterally and with it, the fold of the transversalis fascia which covers the deep ring from the inside (sling effect) like an eyelid. The inferior crus is fixed. The deep ring, besides being covered posteriorly, is tightened by the fibers of the aponeurosis of the transversus and pulled upwards and outwards. When the muscles contract, the deep ring passes under the internal oblique muscle, which, is simultaneously tended and lowered. This protection mechanism is called the "sphincter mechanism".
The simultaneous contraction of the internal oblique and transverse muscles creates the Keith shutter mechanism, which protects the posterior wall of the inguinal canal from endoabdominal pressure As a result of the contraction, the internal oblique muscle stiffens and becomes shorter; the arch straightens, lowers and leans on the inguinal ligament. The same happens to the aponeurotic arch of the transversus muscle.

The spermatic cord

The most important elements of the spermatic cord are: the deferent duct, deferential artery; the testicular artery; the pampiniform plexus. These elements are enveloped by the internal spermatic fascia, which forms a continuum with the transversalis fascia. Externally, we find the cremaster. The cremaster is the continuum of the internal oblique muscle and pulls the testicle up towards the superficial inguinal ring. The genital branch of the genitofemoral nerve innervates it. It is vascularized by the funicular artery, a branch of the inferior epigastric artery.
In women, the content of the inguinal canal is the round ligament, accompanied by some unimportant vessels (artery of the round ligament) and by nerves (iliohypogastric, ilioinguinal, and genitofemoral).

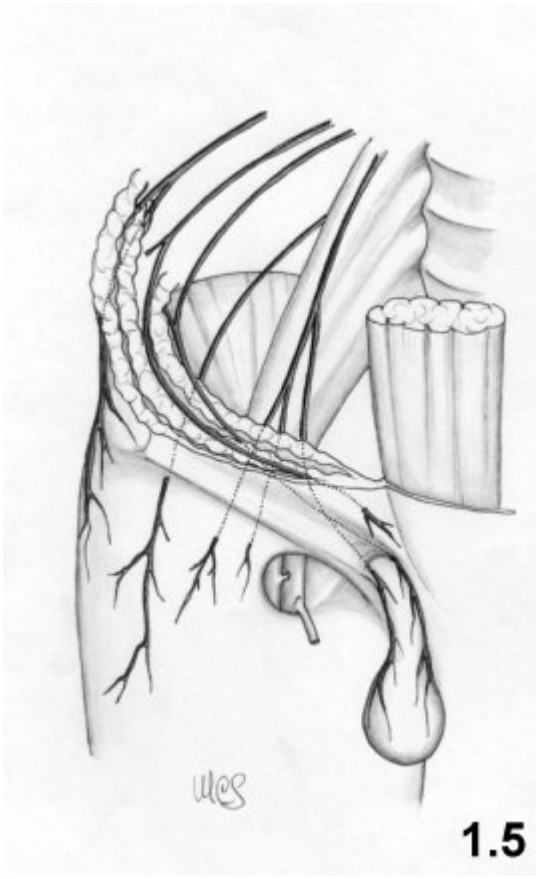
The preperitoneal tissue and the peritoneum

The preperitoneal tissue is mostly fat and is located between the transversalis fascia and the peritoneum. It is easily separable from the transversalis fascia.

The vessels

The inferior epigastric vessels, (artery and two veins) stem from external iliac vessels. They pass by the deep inguinal ring, below and medially with respect to it, and proceed obliquely towards the posterior surface of the rectus muscle. The vessels are located between the peritoneum and the transversalis fascia. At times they adhere to the transversalis fascia. It is advisable not to transect and tie the inferior epigastric vessels, but in cases of hemorrhage or when a prosthesis has to be positioned, this may be done with the utmost tranquillity.
The funicular vessels stem from inferior epigastric vessels and reach the funiculus through the deep ring or a small hole directly under this coming very close to the transversalis fascia.
The iliac and femoral vessels pass through the lacuna vasorum. They are easily recognizable in laparoscopic surgery. In traditional hernia surgery risk of lesion to these big vessels is quite remote. But excessive stenosis of a crural hernial defect during repair may cause compression of the femoral vein, which is located medially to the artery and is often more easily detected through palpation than at sight.

The nerves

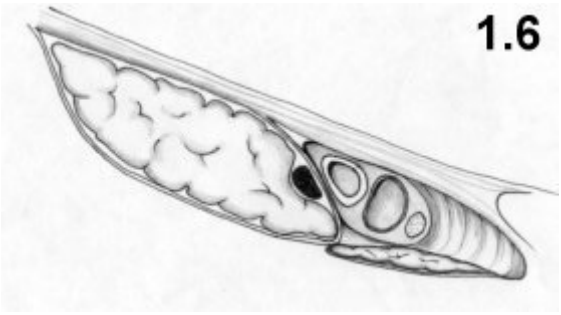


The nerves (Fig. 1.5) which are greatest interest are:

- *The terminal cutaneous branches of the XI and XII intercostal nerves.*
- *The genital branches of iliohypogastric and ilioinguinal* run parallel to each other. The iliohypogastric nerve runs above the ilioinguinal one before turning inwards. At the iliac crest they pass between the transversus and the internal oblique muscles. In the inguinal canal they are located between the internal oblique muscle and the external oblique aponeurosis together with the funiculus. During hernia surgery, the subcutaneous terminal branches, which pass through the external oblique aponeurosis, can sometimes complicate the mobilization of this layer. It is necessary to isolate them; if, on account of their position, they run the risk of being strained or becoming tangled in the suture they should be transected to avoid postsurgical pain.
- *The lateral external cutaneous nerve and the femoral branch of the genitofemoral* innervate the skin of the thigh laterally down to the knee as well as the skin on the upper part of the "Scarpa's triangle". These are rather marginal to the operating area during hernia surgery.
- *The genital branch of the genitofemoral nerve* penetrates the inguinal canal through the deep ring. Together with the funicular vessels, it runs posterior to the funiculus and innervates the cremaster. It then exits through the superficial ring and innervates the skin of the scrotum or the major labium as well as the superomedial part of the thigh.

These nerves are almost all sensory nerves. The only motor nerve is the genital branch of the genitofemoral nerve, which innervates the cremaster.
It is important to know the nerve path well, not only to perform local anesthesia, but also because if cut or caught up in the stitches can cause hypoesthesia or postoperative pain, respectively. One may say that even when these nerves are cut the ensuing, hypoesthesia diminished over time and is confined ultimately to small skin areas.

The femoral canal and the Cooper ligament (Fig. 1.6)



The femoral or crural canal is delimited:

- anteriorly, by the iliopubic tract and immediately to the front by the ilioinguinal ligament
- medially, by the Gimbernat ligament
- posteriorly, by the pectineal fascia, which, at level of the pectineal line, grows thicker and is called the Cooper ligament
- laterally, by the arcus ileopectineus which covers the psoas muscle and separates the femoral nerve from the femoral vessels.

Medially to the vein, the femoral canal is closed by the transversalis fascia, which at this point is known as the septum femorale, and is crossed by a number of lymphatic vessels. Crural hernias generally occur medially to the femoral vein, due to weakness in the femoral septum; less frequently prevascular hernias are known to occur.

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2 APPROACHES

All modern hernia surgery consists in three phases:

- reaching the sac and the hernia defect
- treating the sac
- repair

The sac and the hernia defect may be reached through three different surgical approaches: inguinal, preperitoneal and transperitoneal.

The inguinal approach

The inguinal approach is the most direct. The hernia defect may be reached anteriorly in two ways:

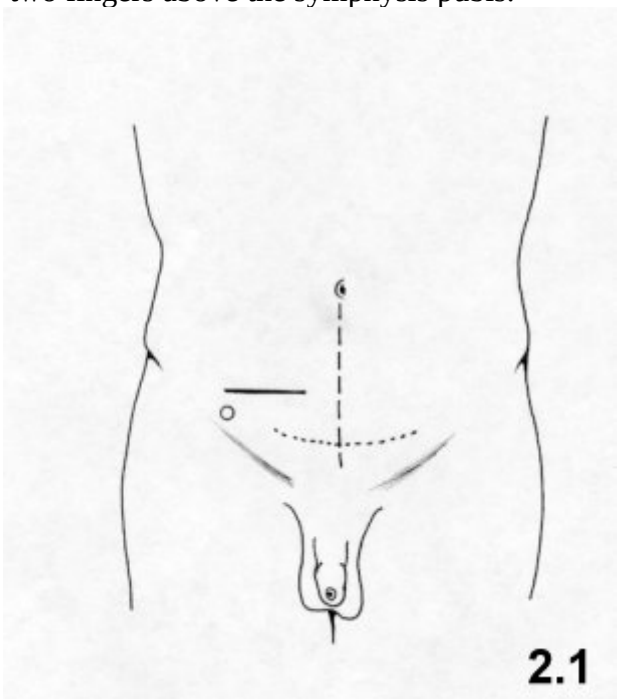
1) through an oblique incision in the skin, parallel to the groin, and medially at about a distance of two fingers from it, or
2) by a transverse incision at deep inguinal ring level.

The external oblique aponeurosis is incised following the grain of the fibers and the superficial ring is opened.
The spermatic cord is isolated starting from the pubic spine and drawn back laterally.
In indirect hernias, the sac is isolated from the elements of the spermatic cord, once the internal spermatic fascia has been opened. In direct hernia, the sac is reached easily after cutting the transversalis fascia on the back wall of the inguinal canal.

The preperitoneal approach

The hernia defect may be reached from behind through the preperitoneal space. Today these approaches have been re-evaluated thanks to the advent of laparoscopy.
The most common skin incisions currently used are the following (Fig. 2.1):

- midline umbilico □ pubic;
- transverse suprapubic according to the Pfannenstiel method;
- suprainguinal transversal, two fingers above the symphysis pubis.



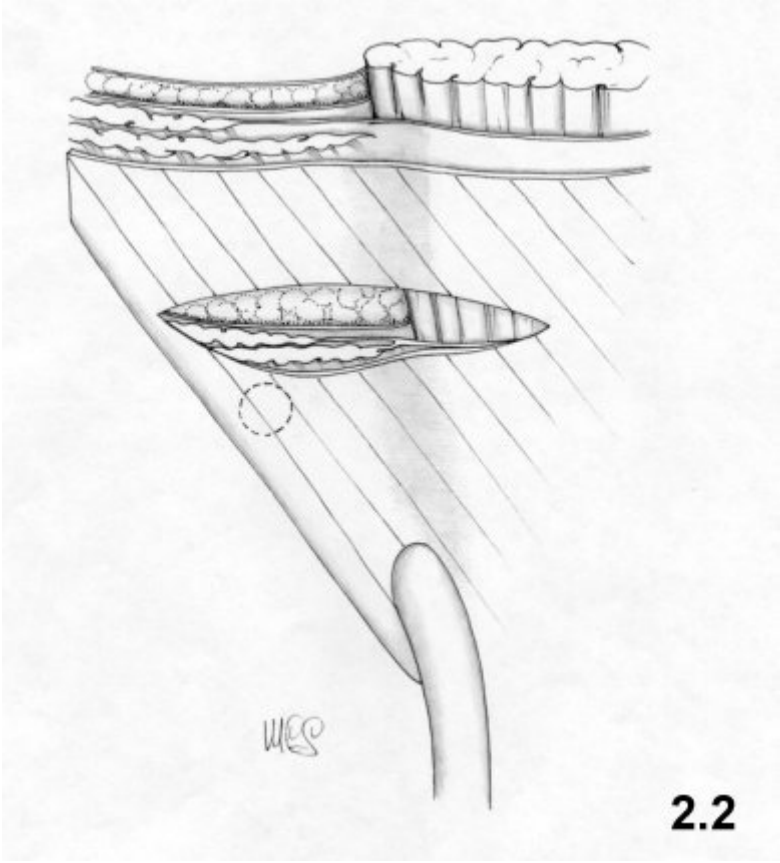
The first two types of incisions allow simultaneous treatment of bilateral hernias.

Dissection of the deep layers

Through a midline incision, passing through the two rectus muscles the preperitoneal tissue is reached.
In the Pfannenstiel incision, the sheath of the rectus muscles is incised transversally and detached from the underlying level.

The peritoneum is then separated from its wall until the affected inguinal area is reached. The epigastric vessels remain attached to the wall.
The suprainguinal incision must be executed slightly above the deep ring. The incision is made transversally along the rectus sheath starting from the midline and across the internal oblique and the transversus muscles. This way the transversalis fascia may be reached (Fig.2.2).
The lateral edge of the rectus muscle is retracted towards the midline. Then the transversalis fascia may be incised longitudinally down the lateral edge of the rectus muscle or, as Nyhus proposes, transversally, to reduce herniation of the wound. Under no circumstances should the peritoneum be cut. This incision leads to the inferior epigastric vessels which, normally, must be interrupted and tied.

Then, continuing to separate the peritoneum from the wall, the hernial sac is reached.

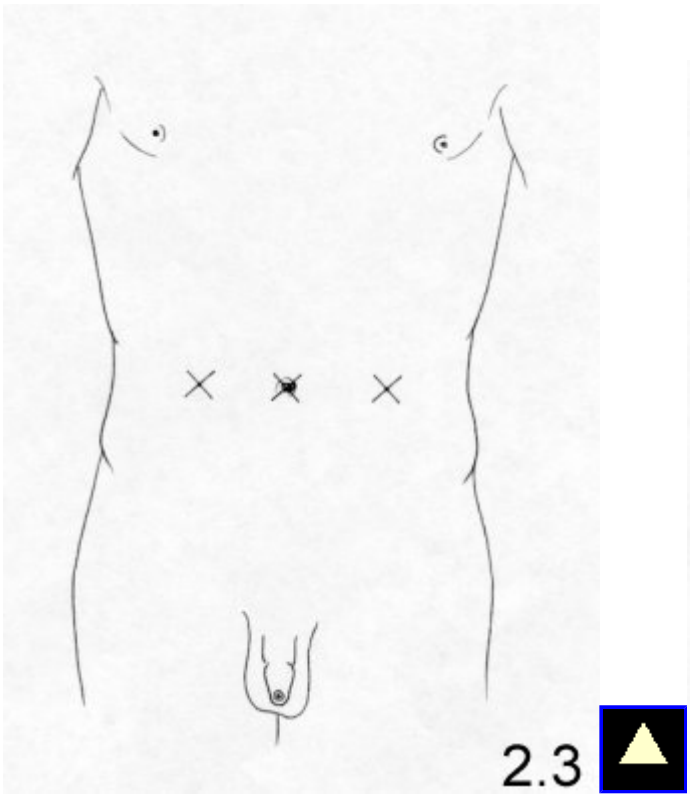


The laparoscopic approach

E.Nicolo'

Even if an intraperitoneal laparoscopic approach exists, a preperitoneal one is generally preferred. The preperitoneum may be reached directly, without opening the peritoneum, as well as transperitoneally.
In the latter case, the hernia defect may be reached through the inner side of the abdomen cavity by an incision on the parietal peritoneum which will later be sutured.
The laparoscopic approach requires specific experience and a good "inside" knowledge of anatomy. (See Figs. 5.11 and 5.12).
The transabdominal preperitoneal approach
After having performed a pneumoperitoneum, a laparoscope with a 30-degree view is introduced through the umbilicus. Two trocars are inserted at the lateral edge of the rectus muscle, one on the left, the other on the right, at umbilical level (Fig. 2.3).
The total extraperitoneal approach
A vertical incision, 1-2 cm long, under the umbilicus and 1 cm lateral to the linea alba, on the side opposite to the hernia, is made. (Fig. 2.4). The anterior rectus sheath is incised, the muscle is retracted and a special balloon probe, which slides along the posterior sheath of the rectus muscle

until it reaches the pubic bone, is inserted. The optics are inserted, the balloon is inflated to separate the preperitoneum. After 3-4 minutes, the optics are removed. The balloon is deflated and the probe is removed. Through the same hole, a sealed trocar is introduced and carbon dioxide blown in. Two trocars are inserted at the midline, one above the pubis, the other half way between the umbilicus and pubis (Fig.2.4).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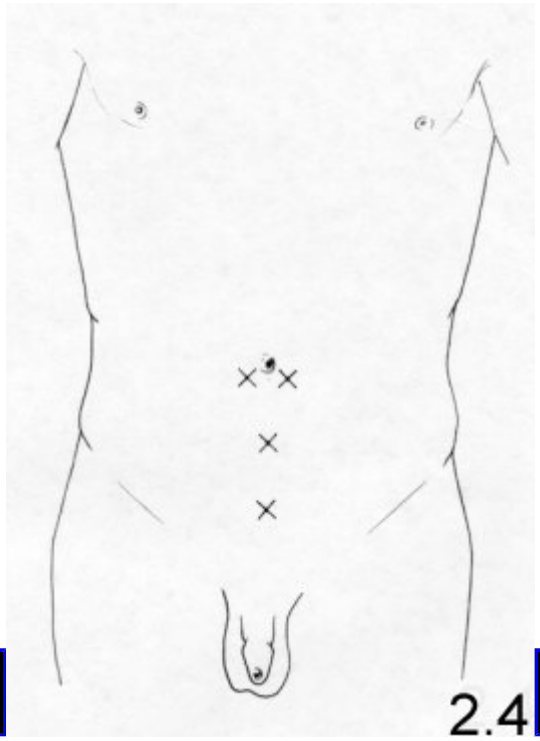
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Comments

The inguinal approach

Is undoubtedly the most frequently chosen**.**

Advantages:
- the possibility of performing under local anesthesia
- direct and easy access on all anatomic levels
- very low risk of lesion of large vessels.

Disadvantages:
- difficult dissection in hernia recurrence with added risk of lesion to testicular vessels
- frequent traumatism of the inguinal canal nerves with consequent hypoesthesia and neuralgia

The preperitoneal approach

In many cases this requires a general anesthesia, except in the case of suprainguinal incisions.

Advantages:
- in hernia recurrences, the difficult dissection of the scar tissues is avoided. The risk of testicular vessel lesion is reduced.
- elimination of inguinal canal nerve traumas
- the possibility of treating hernia during operation for other pathologies
- bilateral hernias may be treated simultaneously if a midline incision is performed

Disadvantages:

- limited possibility of performance in local anesthetic
- increased width and depth of the operating field compared to the inguinal approach
- impossibility of reaching surface layers of the inguinal region
- practically imperative use of prosthesis due to the poor results with use of direct suture and avoid risk of hernia on the wound.

The laparoscopic approach

Perhaps, because it is very recent, it is still too soon to express a proper evaluation of this new approach and when it is indicated. Problems of training, the development of new methods and instruments are being developed. On the one hand, enthusiasm for novelty and the strong influence of the biomedical industry are keenly felt, but on the other, distrust towards new and more sophisticated techniques exists, also because these techniques are difficult to acquire.
Those who advocate this method assert that the risk of trauma is low, that postoperative pain is mild and that immediate resumption of physical activity is possible, and that no risk of ischemic orchitis exists. The criticism this technique arouses is similar to that for extraperitoneal techniques.

Concluding, the inguinal approach is still the most frequently chosen. Only in particular cases are different approaches preferred.

Cases in which preperitoneal or laparoscopic approaches are indicated:
- complicated hernia recurrence and multiple recurrence
- bilateral hernias to be treated simultaneously
- treatment of hernia during operations for other ailments.

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3 TREATMENT OF THE SAC

The hernial sac is an outward bulging of the parietal peritoneum. The sac itself consists of a neck, a body and a fundus. The neck is the proximal portion surrounded by the hernia defect.

Isolation of the sac

For more than a century, the necessity to isolate the sac from the transversalis fascia beyond the neck has been known.
Through the inguinal approach, the isolation of the sac in direct hernias is quite straightforward. In indirect hernias, sometimes the sac may reach the scrotum or adhere to the funiculus. In these cases wide dissection should not be performed because it might provoke distal vein thrombosis and ischemic orchitis: the sac may be isolated from the neck up to the pubis and divided at this point. The body and the fundus may be left in situ.
The preperitoneal approach: in direct hernias the isolation of the sac is again straightforward. In indirect hernias, the sac is easily isolated by applying medium traction on the peritoneum. In case of stubborn adhesions, the sac may be divided at the level of the neck and left in situ.

Resection of the sac

Having isolated the sac beyond the neck, the complete resection and closure, with ligation or high suture of the sac, are carried out in the traditional manner.
Alternatively, after the resection of the sac, the peritoneal gap may be left unsutured. Some Authors hold that this does not cause additional complications because the peritoneum heals immediately and completely. Postoperative pain should be less because less phlogosis of the parietal peritoneum occurs.

Abandonment of the sac

The abandonment of the sac, without even opening it, in the preperitoneal space may be performed in both direct and indirect hernias. Abandonment causes multiple folding of the walls and an effective elimination of the sac, which will not expand.

Comments

Personally, I prefer the abandonment of the sac in the preperitoneum, a practice which is possible in most cases. I tend to avoid ligations when the sac has to be divided to prevent traumatic separation of the body and fundus.
Abandonment of the sac, which I have performed during thousands of operations, is easy and safe because there is no risk of viscera lesion, which may occur in cases of resection. When this not too rare kind of viscera lesion occurs, it usually involves the bladder. In any case, the opening of a sac with thick walls and /or in the presence of sliding hernia may create problems. Another advantage related to sac abandonment, is that postoperative pain is reduced noticeably.

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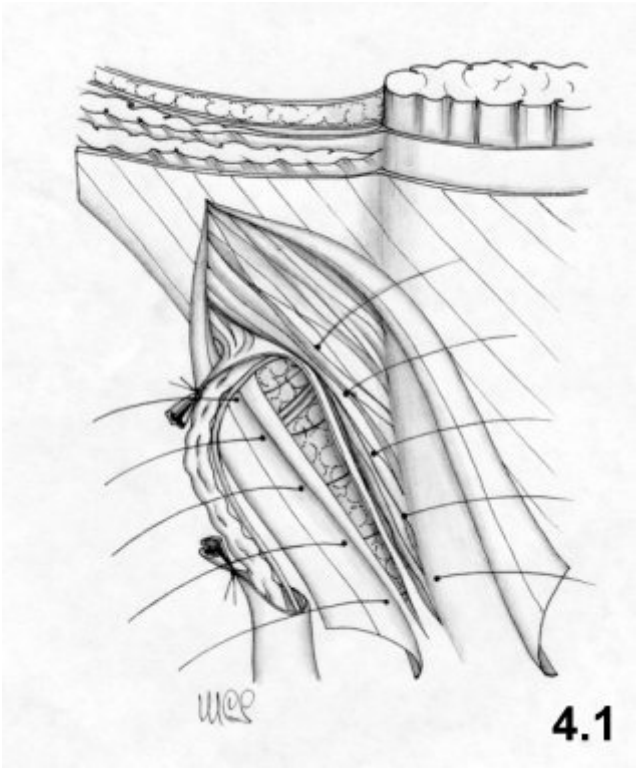
4 REPAIR TECHNIQUES THROUGH DIRECT SUTURE

Repair may be performed either by suturing the anatomic layers (herniorrhaphy) or by inserting a biocompatible mesh in order to reinforce the tissues (prosthetic hernioplasty). The tissues themselves may be used for the same purpose (hernioplasty).
The *Bassini, Postempski, McVay, Shouldice and Marcy techniques* are all performed availing of the inguinal approach and are the most frequently used at present.

The Bassini Repair

In order to perform the Bassini technique correctly, the resection of the cremaster and an incision of the transversalis fascia from the deep inguinal ring to the pubic spine are mandatory. These phases are often, omitted, and wrongly so. The repair of the inguinal canal takes place upon two planes. The deep layers are sutured using separate stitches, one centimeter apart. The suture starts from the pubis and medially includes three layers: the internal oblique muscle, the aponeurosis of the transversus muscle and transversalis fascia; laterally, the iliopubic tract and the inguinal ligament (Fig. 4.1). The suture reaches deep ring, which is tightened in such a way as to avoid compression of the cord vessels.
Once the funiculus is placed to the front of this suture, the external oblique aponeurosis is sutured. At lower level, the "joined tendon" is not always well represented, in this case the first stitches are placed on the rectus sheath.



Principles of the technique
Bassini's intention was to reconstruct the normal anatomy. Mistakenly, he believed it would also reestablish the normal physiological defense mechanisms, which he believed depended on the obliqueness of the canal and the level variation between the superficial and deep rings.
Comments
On no other technique has so much been written. Many surgeons continue to believe strongly in this technique, even if the reported results are both good and bad. This ambiguity can be due to incomplete follow-up, good/bad execution of the technique, the experience/inexperience of the

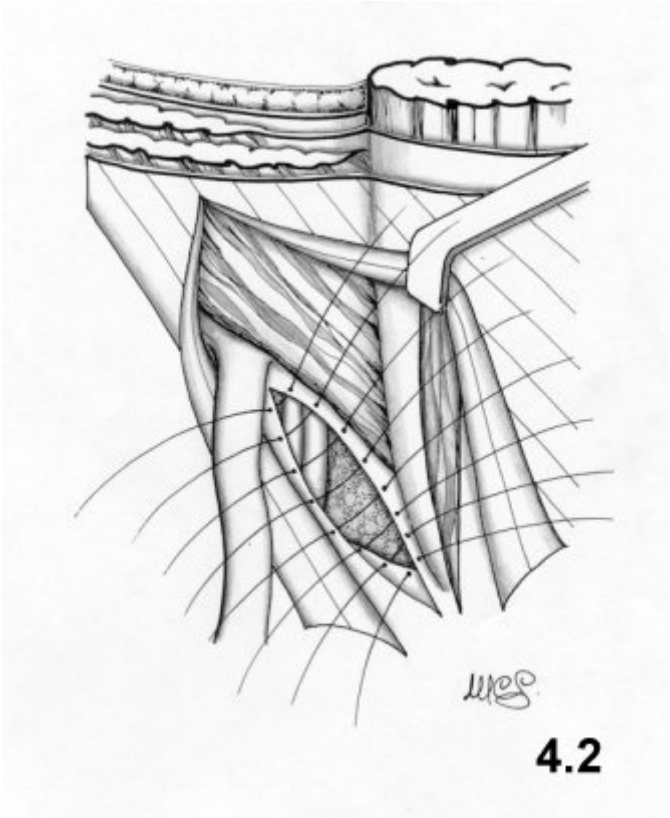
surgeons. What is unquestionable, though, is the high incidence of recurrence (about 10%).
The incidence of recurrence may be considered the most noticeable drawback of the Bassini technique, although there are others.
Above all, physiology is not respected; in fact, deep inguinal ring, anchored to the inguinal ligament, loses its mobility and its normal defense mechanisms. The transversus and internal oblique muscles are united, while in normal conditions each of them move independently complementary to the other (sphincter effect).
Moreover, the technique does not follow principles of tissue synthesis:
- the stitches that pass through the entire wall may rupture the tissue and create new hernia defects.
- the muscles are not usually fit for sutures: they rupture easily, lose motility and form scar tissue.
- the suture between the rectus sheath and inguinal ligament, performed when the internal oblique muscle is atrophic, is under strong traction due to poor tissue elasticity.
Because it is known and performed worldwide, the advantages of the Bassini technique are that is easily performed and learnt.

The Postempski or Halsted Repair

This method differs from that of Bassini in one way: the repair of the external oblique aponeurosis occurs behind the funiculus. The superficial ring is located upwards and aligned with the deep ring. The funiculus is made to run through the subcutaneous tissue.
Principles of the technique
This technique aims at eliminating the weak point in the Bassini technique (the inferior area) and at creating a scar wall formed by the fusion of the posterior and anterior layers.
Comments
This technique creates a reliable reinforcement of the weak zone near the pubic spine but creates alignment between two weak points: the superficial and deep ring. This alignment has been criticized because it eliminates the defense of the external oblique aponeurosis on the deep ring, already deprived of the sphincter effect. Nevertheless, the incidence of recurrence is lower in Postempski□s technique than in Bassini's. The recurrences of direct hernia at the inferior angle are very rare, while those of indirect hernia are the same as in Bassini. These results are obvious, since the external oblique aponeurosis supports the levels below. The risk for recurrence is linked to the resistance of the deep layers and to the deterioration of the physiologic defense mechanisms.

The McVay Repair

This technique is in keeping with current inguinal and crural hernia therapy and with the supporters of the Fruchaud thesis on the need (on principle) to treat the myopectineal orifice. Lotheissen devised it in 1897, but without practicing a relaxing incision on the rectus sheath; the suture traction was excessive.
The transversalis fascia must be opened as far as the pubis to reach the Cooper ligament. Repair occurs on two layers. The deep layer is created, using interrupted stitches to join the transversus aponeurosis + transversalis to the Cooper's ligament as far as the femoral vein, which should not be compressed. Then, the aponeurotic layer is sutured to the femoral sheath and to the iliopubic tract as far as the deep ring. A relaxing incision on the rectus sheath is performed in advance to avoid excessive suture tension. (Fig. 4.2). The inguinal ligament and the internal oblique muscle are not involved in the suture.
The funiculus is relocated on this layer and the external oblique aponeurosis sutured.

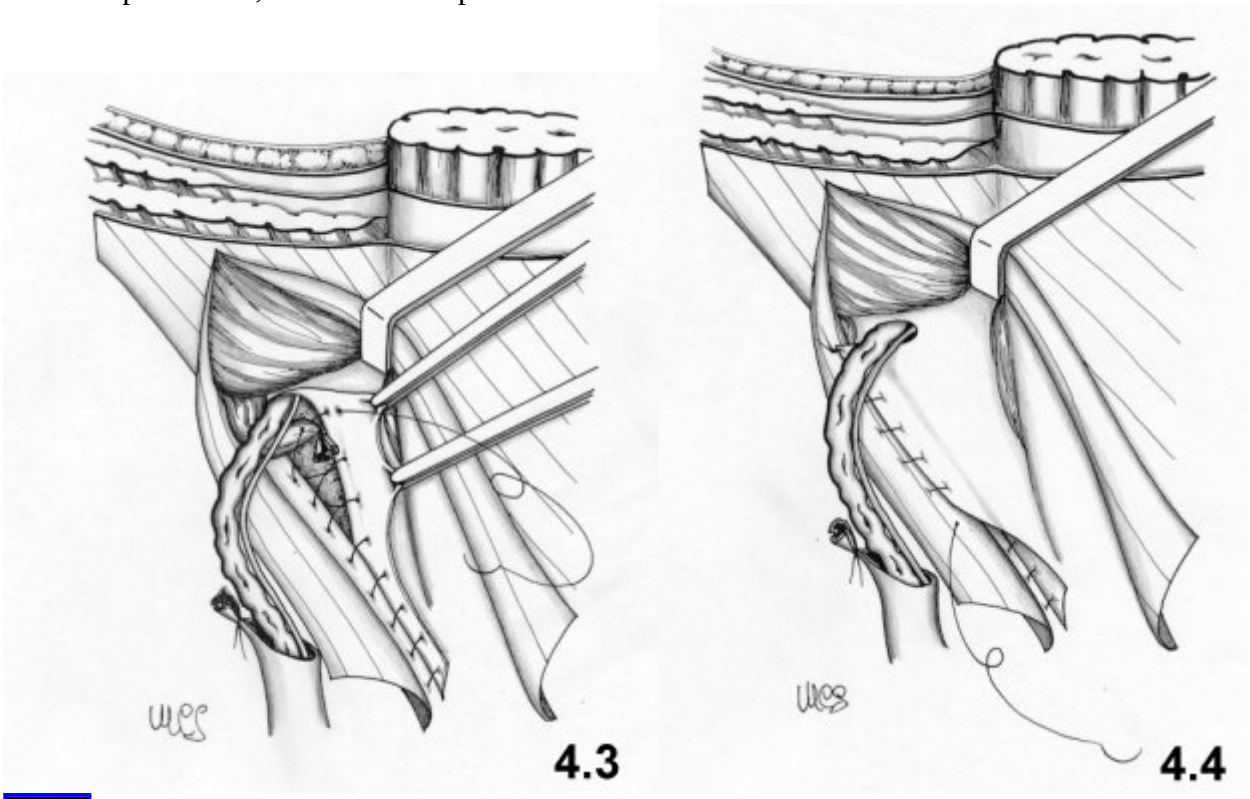


Principles of the technique
This technique aims at anatomical repair of the whole myopectineal orifice: in fact the Cooper ligament is considered to be the perfect continuation of the transversalis fascia.
Comments
This technique respects both anatomy and physiology, because it does not compromise the motility of the deep ring and internal oblique muscle. But the repair of the deep ring does not guarantee solidity, therefore an indirect hernia may form. Frequently, repair is not well performed because the transversalis fascia near the deep ring is often dystrophic and very thin. The suture between the transversalis fascia and aponeurosis of the transversus muscle and the Cooper ligament seems unreliable, because it may come under tension. Also, the thin aponeurotic layer, if not protected sufficiently by the internal oblique muscle, may yield.
Nevertheless, this technique proves more successful than Bassini's. The incidence of recurrence has shown to vary from 3.5% to 7.5%. I think that these results are linked to the fact that physiology is respected and that the rectus muscle may expand laterally. As a consequence, the weak zone is reduced.

The Shouldice Repair

Shouldice's technique was devised between 1945 and 1953 optimizing the Bassini technique. For example, suturing with an overlapping of the transversalis fascia (Harrison 1922).
Resection of the cremaster and opening of the transversalis fascia from the deep ring to the pubic spine are mandatory as well as systematic exploration of the crural ring. Repair is performed with three continuous doubleline ("back and forth") sutures.
The first retrofunicular suture line joins the inner surface of the transversalis fascia (close to the lateral margin of the rectus muscle) to the iliopubic tract, beginning from the pubic spine up to the deep ring. The suture reaches the deep ring, and includes the proximal stump of the cremaster in order to repair and reinforce the ring (Fig. 4.3). On its way back, the second suture line joins the medial flap of the transversalis fascia, left over by the previous step, to the inguinal ligament. In this way, a suture with overlapping flaps of the transversalis fascia is obtained (Fig. 4.4). The second retrofunicular suture line, on the way out, joins the margin of the internal oblique muscle to the inguinal ligament near the previous level and on the way back includes the anterior surface of the internal oblique muscle and the inner surface of the lateral flap of the external oblique aponeurosis. Once the suture

has been performed, the distal stump of the cremaster is also included to sustain the testicle.



The funiculus is then replaced at this level.A third doubleline continuous suture passes in front of the funiculus and joins the margin of the lateral flap of the external oblique aponeurosis and the inner surface of its medial flap 2-3 cm from the border. As it returns, the medial flap covers and is sutured to the lateral one. The original technique requires the use of steel thread.
Some changes have been performed to this technique: the abolition of the third and fourth layer and the repair without overlapping of the external oblique aponeurosis flaps. The results do not seem equally encouraging.

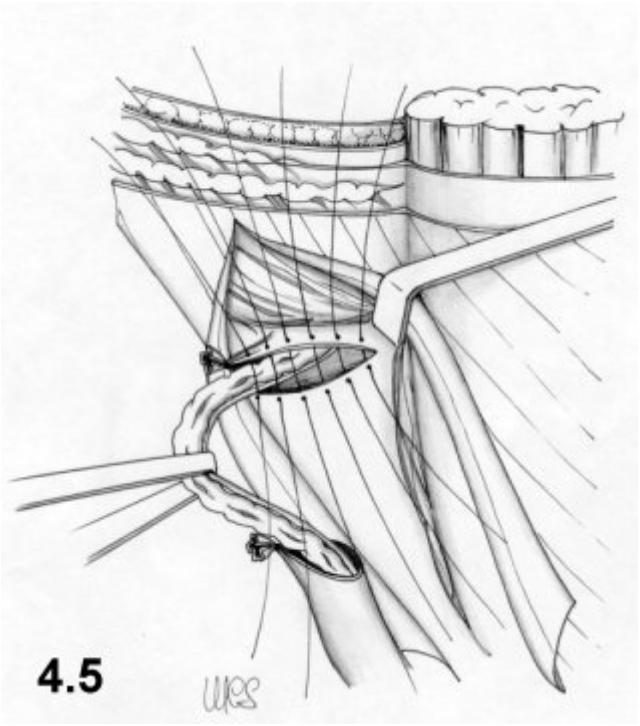
The principles of the technique
A series of improvements and changes concerning the tissue-synthesis have improved the Bassini technique:

- no suture tension occurs because the rectus muscle is mobilized.
- sutures are not aligned and do not involve the whole wall.
- scar surfaces rather than scar borders are produced
- the modeling of the deep ring, using the proximal stump of the cremaster, is improved

Comments
It should be observed that the second suture layer blocks the deep ring on to the inguinal ligament, while the third and fourth layers involve the internal oblique muscle completely. This means that physiology is not respected at all.
On the other hand, tissue-synthesis is respected and an accurate repair of the deep inguinal ring is achieved.
Results proved to be good. The incidence of postoperative recurrence is lower than 1% in cases performed by the surgeons from the Shouldice Clinic. According to them, to obtain these results, a five-year training period is necessary.

The Marcy Repair

The Marcy technique was published in 1871. Although a century old, it still shows interesting characteristics although limited in scope.
This technique implies the resection of the cremaster and a careful exposition of the deep ring. Having treated the sac, the ring is repaired and calibrated with a suture which medially recomposes the transversalis fascia and the transversus aponeurotic layer (Fig. 4.5). A simple suture then repairs the external oblique aponeurosis.



Principles of the technique
This repair technique respects the normal anatomy and physiology of the inguinal canal.
Comments
This technique□s major defect is its lack of treatment of the posterior wall of the inguinal canal.
This technique is suitable for indirect hernias and when both the internal oblique muscle and the transversalis fascia are in good condition, as forms of congenital hernias in babies and youths. In such cases, in fact, resection of the cremaster is not the best choice.
Surgeons very familiar with the deep ring may carry out satisfactory repair availing of the Marcy technique without resecting the cremaster; it suffices to separate the elements of the funiculus from the proximal tract of the cremaster.

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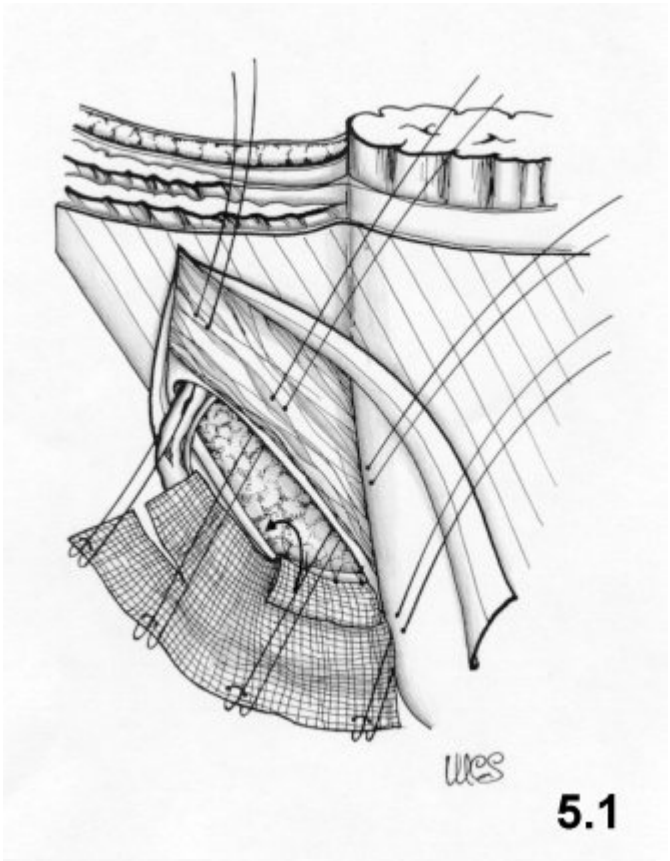
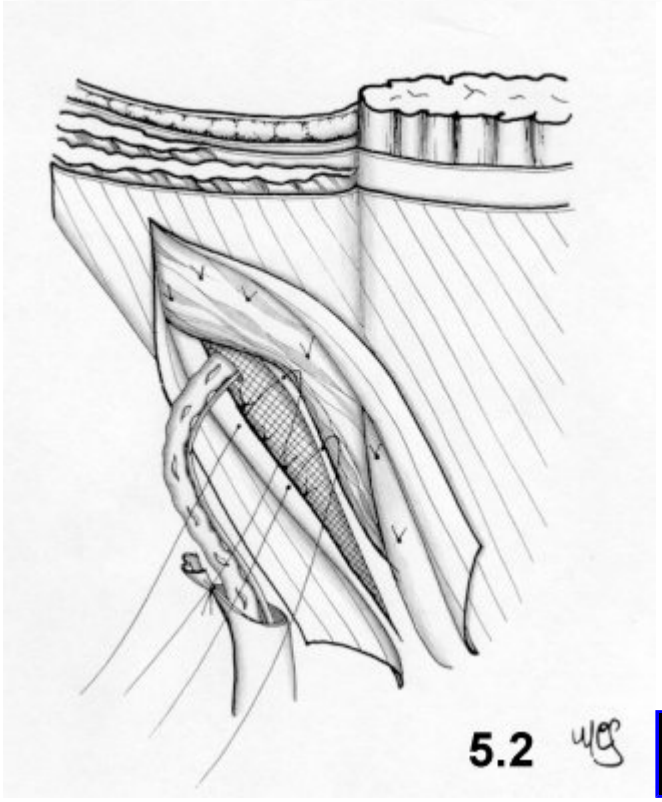
5 MESH REPAIR

Mesh repair is not a feature of traditional methods, because the materials available before polypropylene were inappropriate. From the beginning of the 20th century, numerous techniques using metal mesh or tissue-implants were devised to solve the problem of defects in large hernias, but the results were unacceptable.
At the end of the 1950's, meshes made of plastic materials and well tolerated by the tissues, were introduced. Preperitoneal approaches flourished again and particular attention was paid to traditional methods, which were then improved. New techniques which made meshes a focal feature, even in the treatment of primary hernias, were devised. According those who advocate meshes, these should be used in all cases, because they avoid suture tension completely and reduce the incidence of recurrence considerably.
Today, the most frequently used meshes are those made of polypropylene, Dacron and PTFE.
Current techniques position meshes in the preperitoneum or between the intermediate layer (internal oblique muscle and aponeurosis of the transversus) and the external oblique aponeurosis.
As in traditional methods, the approach may be inguinal, preperitoneal or laparoscopic.
Only the most widely performed techniques will be discussed here.

The Rives technique

This technique was created in 1965. The approach is inguinal. The cremaster is sectioned near the deep ring. The transversalis fascia is incised along the inguinal canal, so that the Cooper ligament is exposed. A preshaped (10 x10 cm) mesh of Dacron with a curved lacuna for the passage of the iliac vessels, is fixed onto the Cooper ligament using 4-5 stitches along the approximately 3-cm hem of the inferior flap. The flap is positioned behind the iliopubic branch to increase the contact surface. The medial flap of the mesh is fixed on the deep surface of the wide muscles by means of a series of U-shaped stitches that penetrate the intermediate layer. A cut is performed on the superoexternal side of the mesh as far as deep ring layer to allow for the passage of the funiculus (Fig. 5.1). The flaps of the mesh are sutured to the wall using more U-shaped stitches, to form a ring, positioned as high up as possible and calibrated around the funiculus. At its inferior-external border the mesh is sutured to the vascular sheath and to the inguinal ligament. Then the surplus mesh is removed along the superoexternal side. The transversalis fascia sutured onto the prosthesis (Fig. 5.2). The funiculus is repositioned and the external oblique aponeurosis sutured.





The principles of this technique

The principles of this technique are complete treatment of the myopectineal orifice and substitution of the transversalis fascia with strong material.

Comments

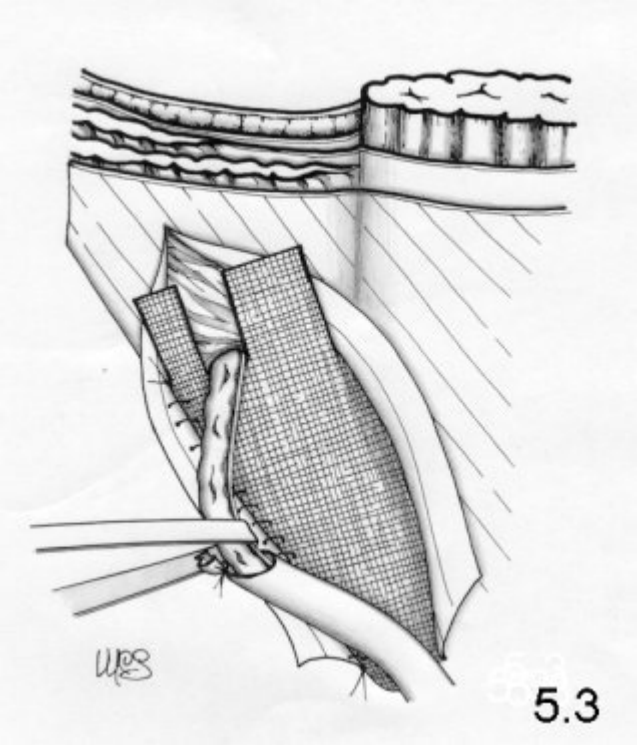
The advantage of this technique is that it requires neither a large mesh nor major dissections, while anchorage of the mesh to the Cooper ligament is strong. The physiology of the inguinal canal is respected.

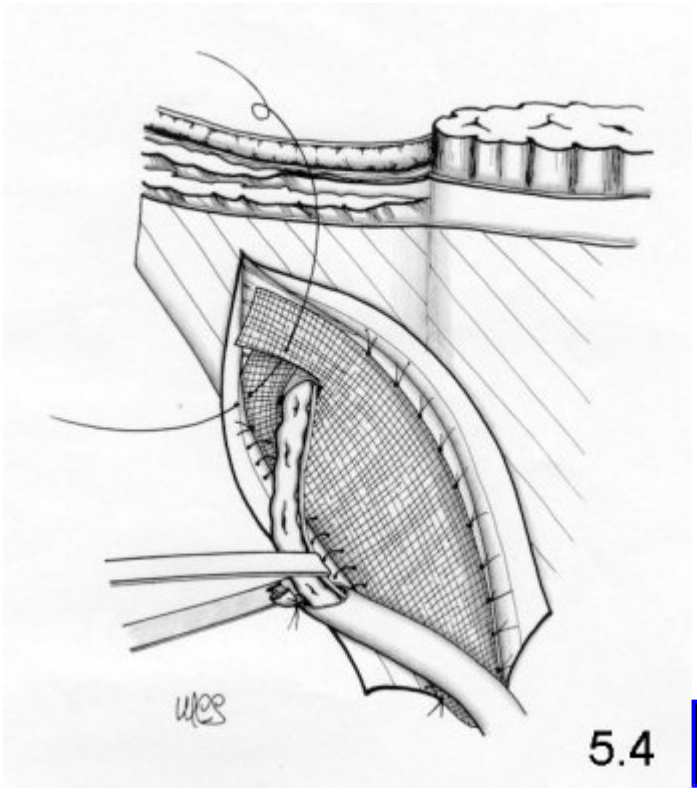
The Author, who, while using this technique witnessed a 0.6% recurrence rate, recommends it in

cases of direct mediumdefect and recurrent hernias. I sincerely retain this technique to be efficient. My only doubts concern the U-shaped stitches that may cut through tissues and open up new hernial defects.
Modern laparoscopic surgery, even if it accedes through other approaches, uses a mesh anchored to the Cooper ligament and to the wall to achieve repairs similar to those obtained by the Rives technique.

Lichtenstein□s "tension-free" hernioplasty

The approach is inguinal. The respect of the iliohypogastric, ilioinguinal and genital branch of the genitofemoral nerves is recommended. To respect the latter the Author recommends to isolate with the funiculus and to divide the cremaster at the level of the internal ring, avoiding to cut the nerve. The hernial sac is sent inwards without ties. The external oblique aponeurosis is separated from the level below, on which a mesh of polypropylene is positioned. An 8 x 16cm spindle shape mesh is cut to fit the inguinal area.
The procedure starts at the inferior-medial angle: the mesh has to cover completely and exceed the pubic spine, then, it is sutured on the fascial tissue, which covers and surrounds the bone without including the periosteum. This suture runs between the margin of the mesh and the inguinal canal to the level of the deep ring . The border of the superolateral mesh is cut to create two flaps: a wider superomedial one (2/3) and a narrower inferior-lateral one (1/3) (Fig. 5-3). The superomedial flap is passed below the spermatic cord and directed cranially. The mesh is stretched under the funiculus and at the level of the deep ring, which is located between two flaps.
The medial margin of the mesh is sutured on the rectus sheath, the superomedial one is put over the inferior lateral one, to circumscribe the funiculus. The two flaps, overlapping one another, are sutured together with one stitch at the inguinal ligament, immediately above the deep ring (Fig.5-4).
Then, the mesh is cut to eliminate the surplus, 3-4 cm above the deep ring. The external oblique aponeurosis is sutured.





Principles of the technique

The Author, a strong supporter of prostheses (polypropylene and monofilament), trusts in the findings of many studies regarding metabolic collagen disorders in adults affected by hernia and speaks of the low trustworthiness of tissues lacking in collagen fiber. He also believes that suture tension should be avoided.

Comments

Much can be said about the lack of collagen. This may be due to a reduction in solicitation of the aponeurosis resulting from muscular weakening. Less strength means less solicitation. Moreover, the excellent results obtained by the Shouldice technique disprove the theory that "collagenlow" tissue is unreliable.

As regards the so-called "tension free" techniques (an intriguing and exciting slogan) I would like to make two observations:

- the absence of tension occurs only at rest, with very slight endoabdominal pressure and a loosened wall. But in the erect position and under strain, tension spreads uniformly to the whole abdominal wall.
- On a non-contractile surface (passive area), the solicitation due to an increase of the endoabdominal pressure, causes what I call the "sail effect" and determines traction on the perimeter of the passive zone proportional to the surface itself.

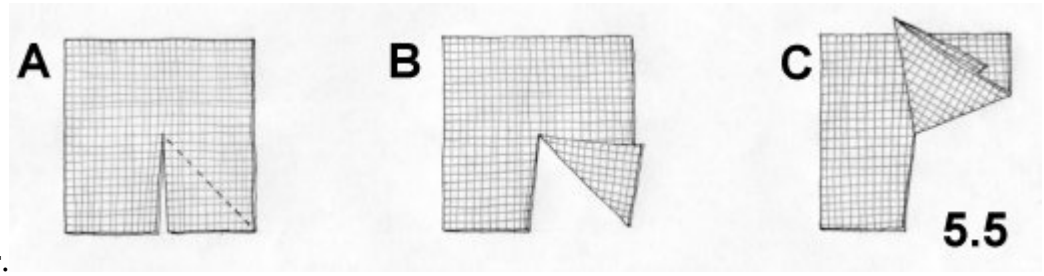
There are still doubts regarding the position of the mesh on top of the internal oblique muscle. The posterior wall is, indeed, reinforced by the mesh, but it is not "sealed". There is a definite risk of intramural hernias, even if they are small and clinically irrelevant. Concluding, physiology is not respected, because the neo- deep ring, made of mesh, is anchored to the inguinal ligament and the internal oblique muscle is entangled in the scar tissue.

Despite these disputable aspects, the technique produces good results. The Author shows a 0.1% recurrence and points out that specific experience is not required to obtain good results.

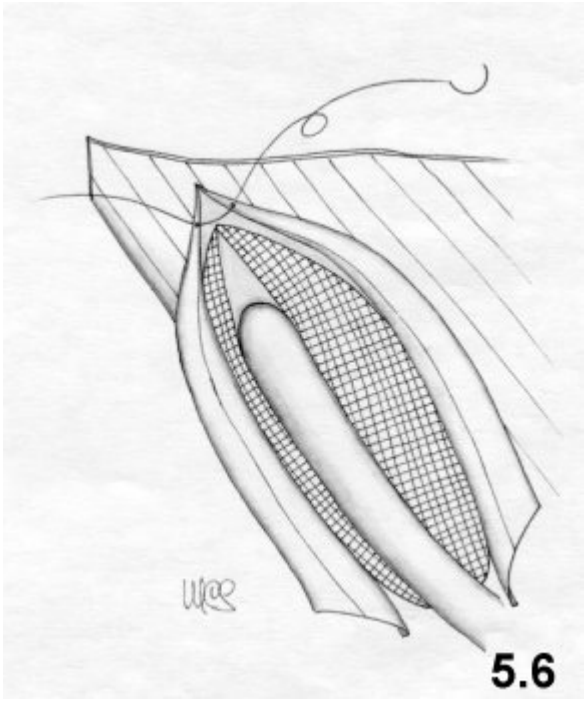
The sutureless "Mesh-Plug" technique

The approach is inguinal.

In indirect hernias, Gilbert uses a plug consisting in a (5 x 5 cm) polypropylene square, on which a cut, from the middle of one side to the center, is made. The plug is folded many times, as shown on Figure 5.5, assuming a roughly triangular shape. It is then inserted into the hernial defect and abandoned. According to the Author the plug expands completely inside the preperitoneum creating a

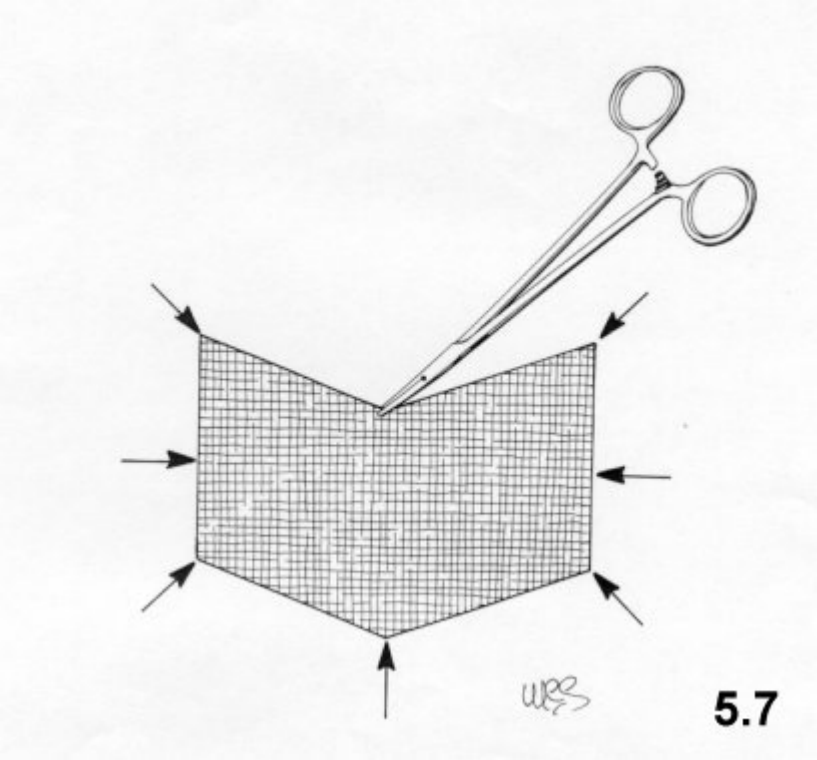


posterior barrier.
A second polypropylene sheet (5 x 9 cm), is shaped to fit and positioned on top of the transversalis fascia and internal oblique muscle. A cut is made on the superolateral margin to allow the funiculus to pass. No stitches are used. The mesh remains in place while the external oblique aponeurosis is sutured in front of it (Fig. 5.6).
The Gilbert technique has inspired many more which differ only in as far as the type of plug and the shape of the mesh positioned in front of the transversalis fascia and internal oblique muscle are concerned.
Robbins and Rutkow suggest other types of plug (conical or preshaped) and perform this technique on all hernias. When the hernial defect is large, a bigger plug is used and is sutured to the edges of the hernial defect to avoid dislocation.

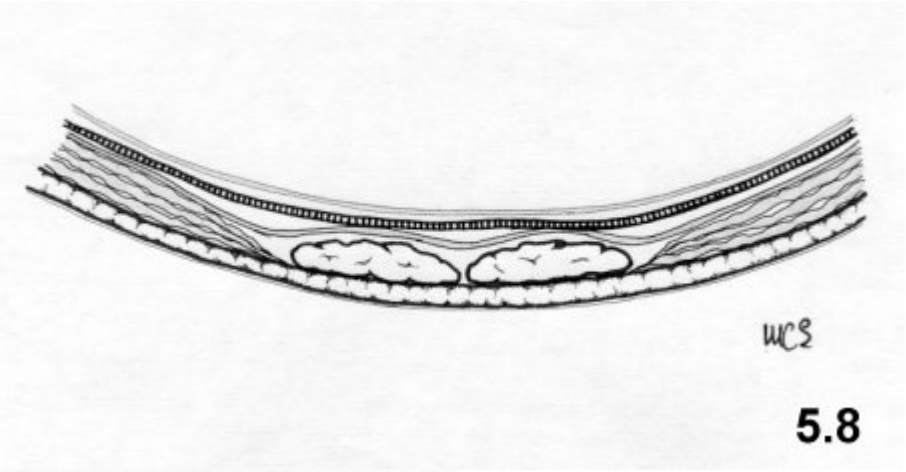


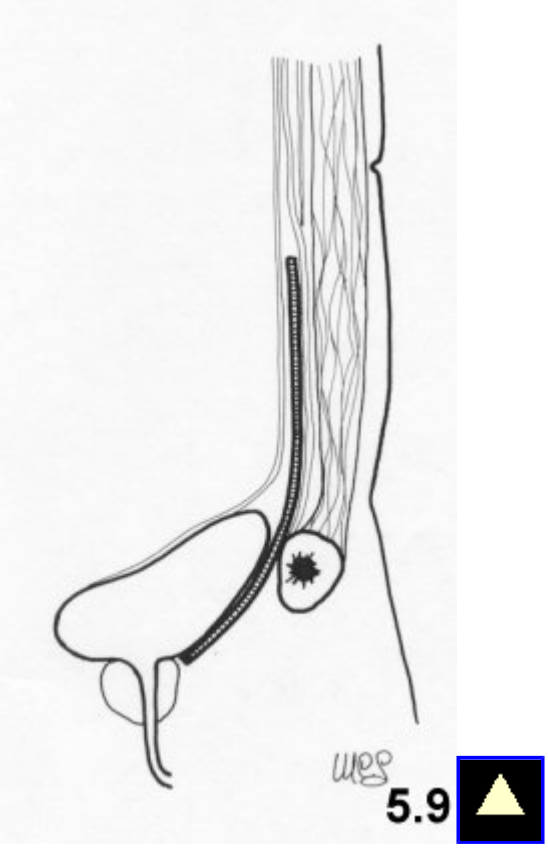
Principles of the technique
Simplicity, rapidity and minimized dissection characterize this technique. According to Gilbert, stitches through the transversalis fascia used to calibrate the deep ring , may distort and weaken the fascia itself, leading to recurrence.
Comments
The most important feature of this technique is its minimization of dissection. No sutures occur to weaken the tissues around the "critical zone", that is the edge of the mesh. Usually this is where greatest solicitation occurs, as shown by the site of recurrences.
It is not true that inexperienced surgeons are in a position to avail of this technique. Hernia treatment requires, in all cases, skill and experience, because, however easy an operation may appear at first sight, it may present sudden and expected difficulties. Repair is not necessarily the most complicated phase of a hernia operation. .
Furthermore I disagree with the use of exceedingly large quantities of mesh as required to make plugs.
The method is presented as physiological and it is in part. However, the mesh positioned in front of the transversalis fascia, provokes a scar reaction capable of entangling the internal oblique muscle, even in the absence of sutures.

The Stoppa technique (with giant extraperitoneal mesh)
Stoppa elaborated this technique on the basis of a previous study by Mahorner and Goss (1962), eliminating the stitches used to anchor the mesh to the wall.
The approach is preperitoneal through a midline umbilico-pubic incision. A wide cleavage in the preperitoneal area is performed, involving the space from the Retzius and bladder to the prostate, reaching laterally beyond the inferior epigastric vessels and below the rectus muscle to the inguinal region. Once the hernial sac is reached, it is isolated by means of moderate traction. If adhesions occur, they should be carefully dissected by introducing a finger into the sac itself. Once the sac is freed, separation continues downwards to the iliac vessels and laterally to the iliac psoas muscle. Then, the testicular vessels are separated as much as possible from the peritoneum, so that they adhere to the wall and do not cross the preperitoneal space where the mesh will be positioned. At this stage the surgeon should stand on the side facing the area to be detached, although during the rest of the operation the surgeon stands on the other side. As soon as the separation has been carried out, a mesh of Dacron is prepared. It should be tailored to fit the patient and corresponds transversally to 2 cm less than the distance between the anterior-superior iliac spines (about 26 cm) and vertically to the distance between the umbilicus and pubis (roughly 16 cm). A very wide V shape is cut into the top and bottom of the mesh (Fig.5.7).



Then, 8 Rochester forceps are positioned at the angles and in the midpoints of each side of the mesh. The preperitoneal area is opened wide and the mesh positioned (Figs. 5.8, 5.9)
using the Rochester forceps. The central lower border forceps is inserted between the pubis and bladder, followed by the inferolateral forceps, then those positioned at the midpoint of the lateral margin and, lastly, those at the superolateral angle. The forceps are then pushed as far apart as possible in order to unfold the mesh. They are then removed with great care to avoid dislocating the mesh. The same sequence is performed on the other side. Again, the surgeon will stand on the side opposite the area to be treated. The mesh is fixed to the wall with one stitch passing through the upper edge midpoint. The laparotomic wound is then sutured.





Principles of the technique

The giant mesh has the task of surrounding the visceral sac and reinforcing the transversalis fascia bilaterally in particular at Fruchaud myopectineal orifice level. The mesh is not anchored by stitches, because it reaches beyond the hernial defect. According to Pascal's hydrostatic principle, it is pushed against the wall by internal-abdominal pressure. This pressure is proportional to the surface of the mesh and blocks the movement.

Comments

This technique respects physiology. The positioning of the testicular vessels along the wall avoids creating gaps in the mesh, a constant source of critical weakness.

It should be underlined: 1) the amount of foreign body introduced is considerable. 2) the separation area is so wide that this technique cannot possibly be performed in local anesthetic. 3) that this kind of surgery requires training. 4) the indications provided are not many: plurirecurrent hernias, very large hernias, and bilateral hernias. It is in any case a very interesting technique and performed by the Author, shows a recurrence rate of 0.56%.

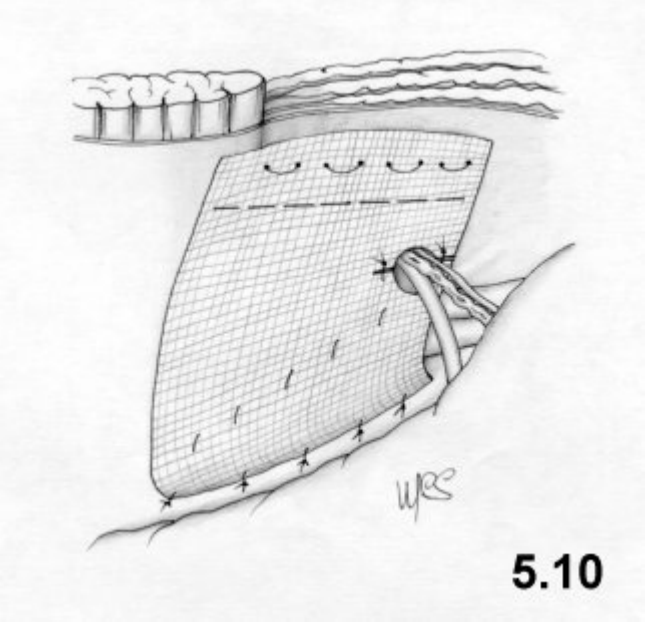
The Wantz preperitoneal technique

This is a variation of the Stoppa technique.

Wantz uses a mesh corresponding to 1 cm less than the distance between the midline and the anterior-

superior iliac spine. The depth of the mesh depends on the patient's body size, usually between 12 and 14 cm. The mesh is inserted (in local anaesthesia) through a transversal lateral incision. The transversalis fascia is incised longitudinally, near the border of the rectus muscle. A large mesh is introduced into the preperitoneum and sutured to the wall where more accessible, but at deeper seated level, the mesh is positioned between peritoneum and the wall, without sutures. The mesh may be fenestrated to permit the passage of the testicular vessels or may be positioned above them, once they have been isolated from the peritoneum for a considerable distance.

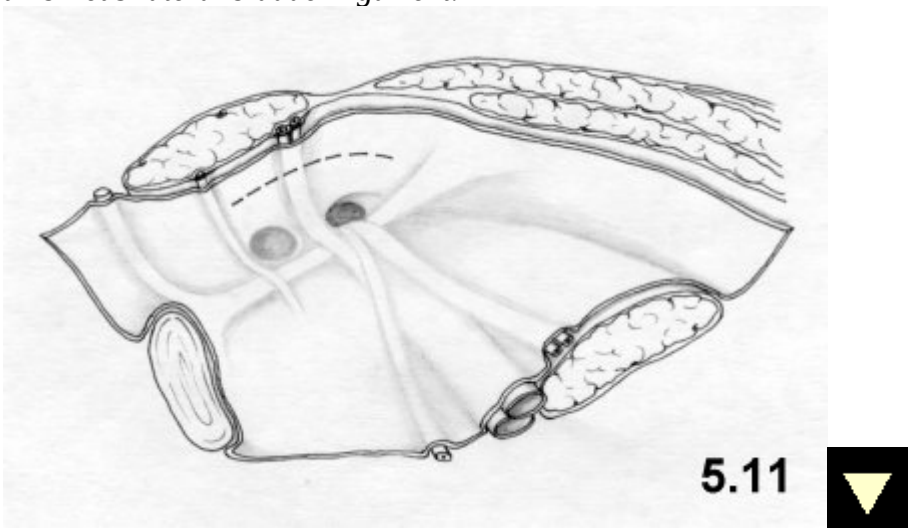
The Nyhus technique
Thanks to Nyhus, the preperitoneal approach was relaunched in 1959. He proposes a suprainguinal approach and suture of the hernial defect from within. In hernia recurrences, he uses a mesh to reinforce the suture of the hernial defect. He uses a cm 6 x 14 rectangle in polypropylene. He fixes it, with unabsorbable stitches, to the Cooper ligament and to the posterior suture of the hernia defect. He positions it and fixes it with U-shaped stitches, behind the operating wound, to protect it (Fig. 5-10).



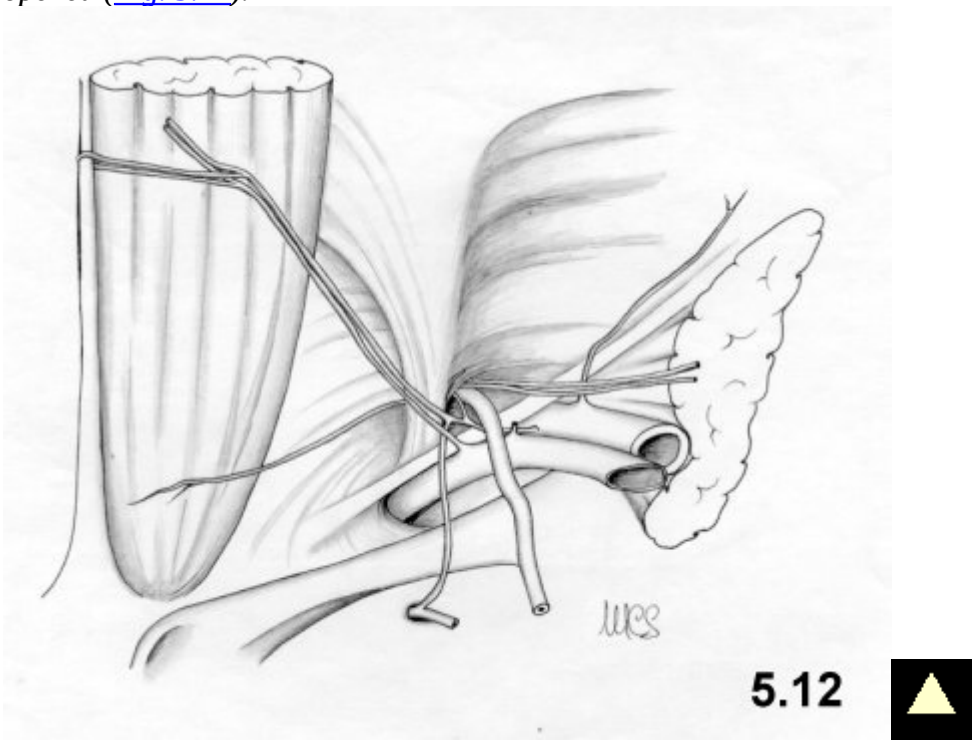
Laparoscopic hernioplasty
E. Nicolo'

The transabdominal, preperitoneal and completely extraperitoneal approaches have already been amply illustrated in chapter 2. The reader should therefore refer back to what has already been said for data regarding the initial phases of this technique.
The transabdominal preperitoneal approach
While the peritoneum is still intact, using hand pressure on the outside of the abdominal wall, the pubic spine corresponding to the midline is identified.
The first structure identified is the umbilicus-lateral bladder ligament (the medial border for the dissection of the peritoneum).
This ligament may be divided using clips to obtain a better vision of the medial portion of the inguinal region. The bladder should also be identified so as to avoid damage to it.
Moving down along the umbilicus-lateral bladder ligament, we find the deferent canal, which stemming from the pelvis follows a medial-lateral path in the direction of the deep inguinal ring.
At this level, the deferent canal joins the internal spermatic vessels, which follow a lateral-medial path, and form an upturned V shape. The highest oint of this V corresponds to the deep inguinal ring and is directed upwards as if pointing to the inferior epigastric vessels.
The inferior epigastric vessels are not always easily identifiable, especially in obese patients, even when the peritoneum is intact.
The parietal peritoneum is cut as high as possible (Fig. 5.11) 2-3 cm from the lateral border of the deep inguinal ring medially to the

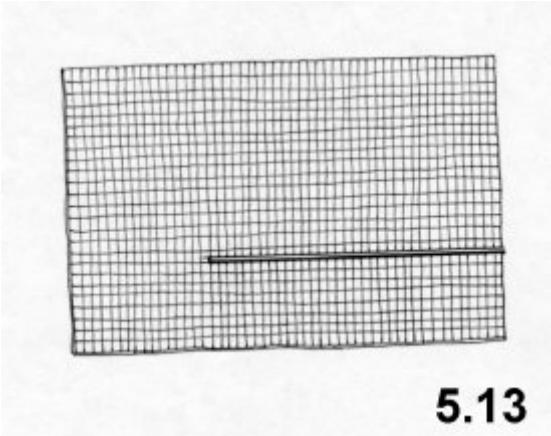
umbilicus-lateral bladder ligament.



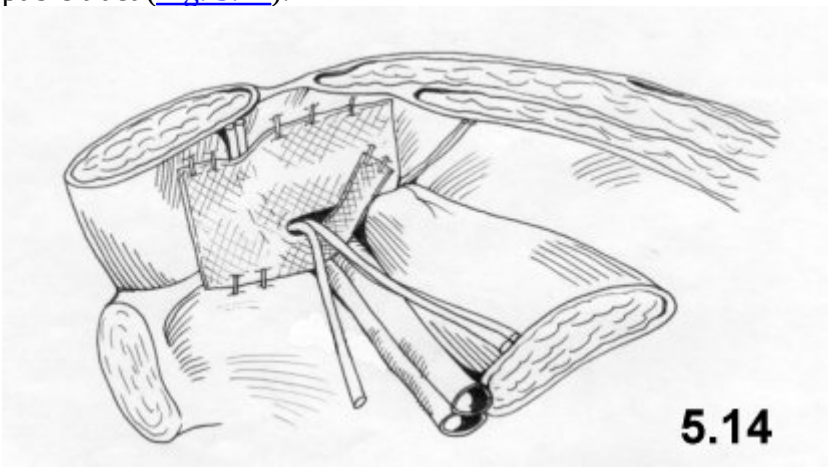
First, the upper peritoneal flap is dissected smoothly. The lower peritoneal flap is treated in the same way up to iliac vessel level.
The lower epigastric vessels if not identifiable while the peritoneum is intact, they will be when it is opened (Fig. 5.12).



During the preparation of the flaps, particular attention should be paid to the peritoneal vessels. The aponeurosis of the transversus muscle is identified above the deep inguinal ring. It is then followed medially to its insertion with the Cooper ligament, close to the pubic spine.
The iliopubic tract (or Thompson ligament) is identified at the lower edge of the deep inguinal ring. It lies parallel to the inguinal ligament, is situated closer to the surface and is not laparoscopically visible.
Following the iliopubic tract, medially, the Cooper ligament is then identified. The circumflexa ilii profunda artery is easily identified, because it is parallel to the iliopubic tract.
In indirect hernia, the sac must be carefully isolated from the spermatic cord and introflexed. When the sac is too large, it may be resected, as occurs in the presence of an adipocele.
In femoral hernia, the Cooper and Thompson lacunar ligaments are exposed. The deferent canal and internal spermatic vessels are isolated smoothly creating a gap between these elements and the iliac vessels.
A Prolene mesh of 7.5 x 12 cm is cut, as illustrated in Figure 5.13 (a cut parallel to the longer side and about 2/3 its length is performed at about 1/3 from the bottom of the shorter side).



The mesh, having been rolled, is introduced into the abdominal cavity. Using a trocar and a dissector, it is positioned so that the small flap passes through the opening previously used by the iliac vessels and deferential canal.
The large flap is used to cover the inguinal ring.
The mesh is fixed, using clips, first onto the Cooper ligament, then onto the abdominal wall to the right and the left of the epigastric vessels. Finally, both borders of the mesh are joined and fixed by clips above the iliopubic tract (Fig. 5.14).



The clips should be inserted above the iliopubic tract to avoid lesion of the iliac vessels and of the nerves immediately beneath this structure.
Clips or continuous stitching suture both peritoneal borders. The trocars are moved under direct surveillance and the pneumoperitoneum is reduced. The skin incisions are closed by intradermic suture.
In cases of inguinal-femoral hernia in women, the mesh is not cut as indicated above, but positioned whole and fixed at the same levels, above the round ligament.

The preperitoneal approach

Once the preperitoneal region has been reached, as described in chapter 2, the same situation as in the transperitoneal approach presents itself, once the peritoneum has been opened.
The operating step is similar to that described in the preperitoneal transabdominal approach. The only difference is that no repair of the peritoneum occurs.

Index

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PART TWO

PHYSIOLOGICAL HERNIOPLASTY

6 A RE-EXAMINATION OF THE INGUINAL REGION FROM AN ANATOMICAL AND FUNCTIONAL POINT OF VIEW

The inguinal region has been studied thoroughly. However, I think that some important anatomical and physiological aspects should be given greater consideration. Therefore, I should like to highlight these aspects, in order to discuss the theoretical premises of the physiological hernioplastic method.

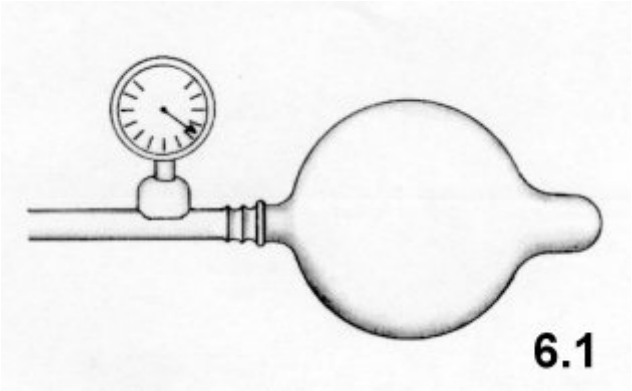
The anatomical and functional aspects of the anterior abdominal wall

The anterior abdominal wall is composed of muscles, fascias and aponeuroses. The fascias cover the muscles. The aponeuroses are flat tendons, anatomical continuations of the corresponding muscles characterized by the collagen fibers aligned with those of the muscles.
The aponeuroses are considerably resistant to traction in the direction of the fibers. When traction

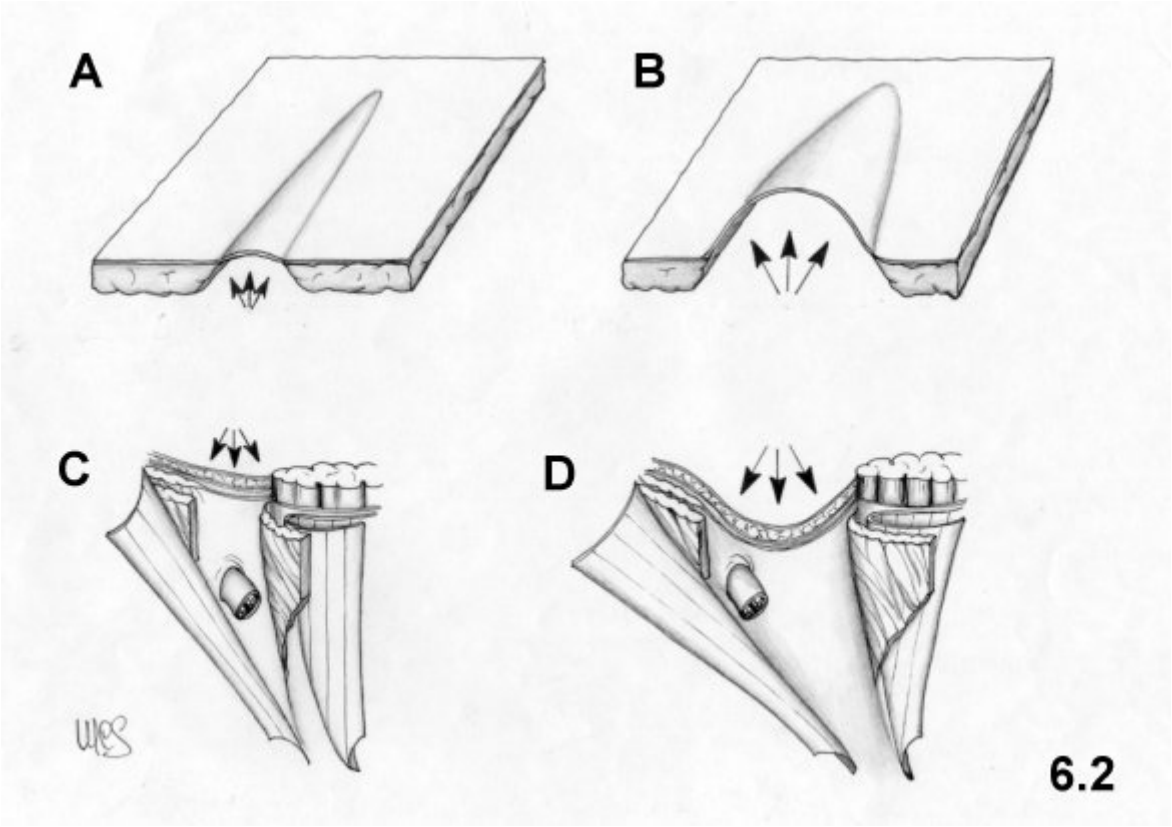
occurs in a transversal direction, the aponeuroses are not so resistant but are elastic.
The muscles and fascias are located in such a way as to form a *synergic system*: at rest, the fascias contain and protect the muscles while, under strain, the muscles protect the fascias, because as they contract they become very rigid.
The posterior wall of the inguinal canal and the linea alba are the only areas not sustained by muscles in the anterior abdominal wall. In normal conditions these are very *narrow*. We use the expression *passive area* to indicate an area of the abdominal wall consisting only of fascia, but no muscle, because it does not react actively to the increase in internal pressure caused by the *prelum abdominale*.

When the abdominal muscles contract:
- the muscles hardens and shortens
- the diameters of the abdominal cavity are reduced
- the fascial zones, protected by the muscles, and not subject to stress, relax
- the aponeuroses are placed under tension in the direction of their fibers
- the endoabdominal pressure increases considerably
- the fascial zones which are not protected by muscles (*passive areas*) receive a solicitation from an endoabdominal pressure proportionate to the dimension and to the bend radius of their surfaces.

To clarify this last statement, it is necessary to consider the effects of the endoabdominal pressure on a passive area according to *Laplace's law*.
***Laplace's law** applies to elastic cylindrical or spherical containers, which undergo an internal pressure greater than the external one: the relationship between the transmural pressure (P), the tension of the wall in a point (T) and the bend radius of the wall in that point " is T= P x R in a cylindrical container, T= P x R/2 in a spherical container".*
More simply, the tension caused by a constant internal pressure upon each point of the wall, in an elastic cylindrical or spherical container, is proportional to the bend radius *at that point*. For example, when a cylindrical balloon is inflated, the proximal tract inflates first and this increases the length of its radius.
As the air enters, the proximal tract inflates while the distal tract, which has a shorter radius, does not and is less stressed even though it is subject to the same pressure (Fig. 6.1). It is surprising to observe how soft the wall of the undilated tract is and how little resistance it opposes, in contrast with the obvious tension and hardness of the dilated tract.



Due to the effect of the prelum abdominale, the passive area, not being contractile, neither reduces its dimensions nor increases its consistency. This is therefore subject to the thrust caused by endoabdominal pressure and assumes a shape comparable to a concave spherical or cylindrical segment, proportionate to the length of its main axes (Fig. 6.2). If a passive area is *narrow*, though long, it will undergo very little stress produced by endoabdominal pressure, because under strain it will assume the shape of a cylindrical segment with a *short radius*.



The structural aspects of the main anatomic layers of the inguinal region in normal conditions and in hernia patients

In males, the inguinal region represents a critical area due to a number of peculiar characteristics:

- the inguinal canal is weak because the spermatic cord which is soft, mobile and opposes no resistance to stress, passes through it
- there is more presence of fascial and aponeurotic tissue and little muscle presence
- the deep and superficial rings represent two weak points.

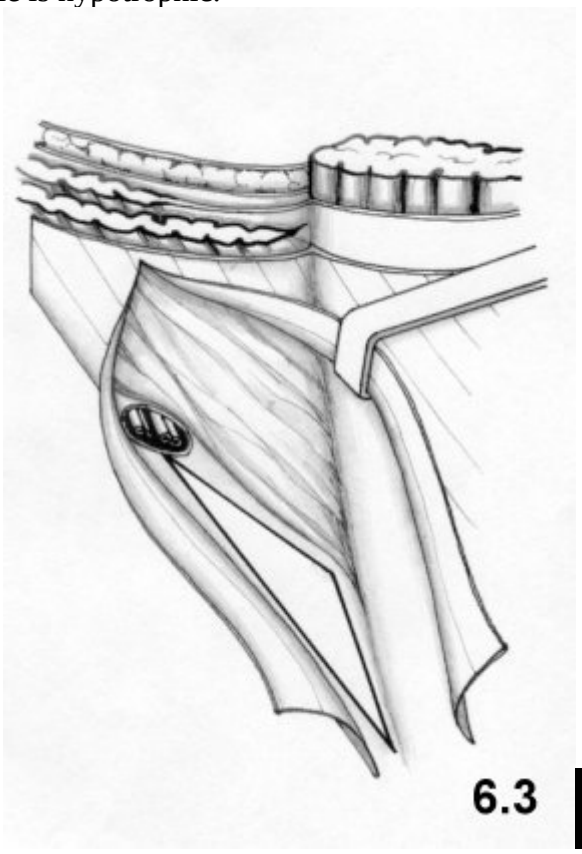
The posterior layer

The posterior layer of the inguinal region consists of the transversalis fascia and of the transversus muscle with its aponeurosis. The deep ring is located at this level.
The transversus muscle is not so well represented and borders on the supero-external side of the deep ring; its aponeurosis borders on the inferior-medial side of the deep ring.
The passive area, corresponding to the posterior wall of the inguinal canal, is formed by the transversalis fascia and by the iliopubic tract. This area is not very strong but is very narrow. Medially the aponeurotic arch of the transversus muscle, adheres to the transversalis fascia, covered by the internal oblique muscle and is characterized by curved and rather thin fibers.
Often in hernia patients, the posterior wall of the inguinal canal is usually wide and thin. In the indirect hernia the deep ring is quite wide, surrounded by weak tissues with adipocele on the lateral side. The transversalis fascia is very thin and often unrecognizable from the external side of the deep ring.

The intermediate layer

The intermediate layer is constituted by the spermatic cord and by the internal oblique muscle. The spermatic cord is soft and therefore alters the synergy existing between the anatomical planes. The internal oblique muscle with its free margin surrounds the funiculus at the exit of the deep ring; then, it continues along the funiculus as far as the pubis. In this way, it forms the whole medial margin of the inguinal canal. The distance between the internal oblique muscle and the inguinal ligament is minimal.
In hernia patients (except for some congenital hernias affecting young people), the lower margin of

the internal oblique muscle seldom reaches the pubis. Its inferior fibers reach the rectus sheath at a variable distance from the pubis, even 3-4 cm. Therefore, a passive area, the *inguinal triangle* (Fig. 6.3) is formed. This triangle shouldn't be confused with the triangle of Hesselbach. Bordering this inguinal triangle are the internal oblique muscle, rectus sheath and the inguinal ligament. Very often the internal oblique muscle is hypotrophic.



The superficial layer

The superficial layer is represented by the external oblique aponeurosis which is characterized by its oblique-oriented fibers.

In hernia patients, the external oblique aponeurosis may be fiberdeficient or hypotrophic at the level of the superficial ring, but usually it does not present large lesions, because the fibers are longitudinally resistant and transversally elastic, unless the hernia is very vast, does not lead to relevant damage.

The normal defense mechanisms of the inguinal region (sling, sphincter and shutter mechanisms)

As an effect of the prelum abdominale, the aponeuroses of the inguinal canal are subjected to two solicitations: one is the contraction of the muscles and the other is an increase in endoabdominal pressure. The former acts only in the direction of the fibers, while the latter is also transversally. The transversalis fascia is not stressed by the muscular traction, but only by the endoabdominal pressure. As stated, the aponeuroses do not resist much to traction along the transversal axis of the fibers. Therefore, *the solicitation, which finds the inguinal canal in a position of greater vulnerability is that provoked by endoabdominal pressure acting in all directions*.

The normal defense mechanisms of the inguinal canal protect from the action of the prelum abdominale the two critical spots: the deep ring, and the posterior wall of the inguinal canal represented only by the transversalis fascia and by the iliopubic tract.

Protection of the deep ring

The contraction of the transversus muscle causes three effects:

- it narrows the ring,
- it moves the ring in a lateral-cranial direction.
- it pulls in a lateral-cranial direction the superior crus of the transversalis fascia's sling. As a

consequence, the exceeding transversalis fascia, surrounding the deep ring, closes on the deep ring itself like an eyelid (*sling effect*).
At the same time, the internal oblique muscle, contracts, stiffens and lowers itself in front of the deep ring. This combined action of the two muscles is called *sphincter effect*.

Protection of the posterior wall of the inguinal canal

The simultaneous contraction of the transversus and the internal oblique muscles creates the *shutter mechanism*: the aponeurotic arch of the transversus stiffens, straightens and draws close to the iliopubic tract. The same occurs for the arch formed by the internal oblique muscle.
In this way, the posterior wall of the inguinal canal is at its most narrow state and is barely stressed by the endoabdominal pressure, according to Laplace's law.

The functional aspects of the inguinal region in hernia patients

In hernia patients, these defense mechanisms are seriously altered.
The sling and sphincter mechanisms can be preserved in direct hernia, but they can be severely altered in indirect hernia.
The shutter mechanism cannot happen at the *inguinal triangle*, even if the internal oblique muscle contracts a lot. This passive area can narrow, but it cannot be covered by the muscle.
When the internal oblique muscle is atrophic, or so weak, as to fail by contracting to act as a defensive barrier, it behaves as a passive area. In this case, the fibers of the aponeurotic arch of the transversus too will undergo solicitations transversally and will easily dissociate one from another.

Deductions

The posterior wall of the inguinal canal has a function we have called *sealing*: a gap in the posterior level will certainly determine the exit of a hernia, which cannot be stopped by the upper layers.
We have many doubts about the emphasis given to the resistance of the transversalis fascia. It can be very resistant to solicitations only when the posterior wall of the inguinal canal is narrow and when the protective action of the upper layers is efficacious.
There is no doubt that the inguinal region wall is a synergic system where each of its levels has a specific role. In any case, I have noticed up to now, that the posterior wall has been overestimated, while the other two anatomic levels, even if indirectly involved in the formation and development of a hernia, have been underestimated.
The other two anatomic layers are: the internal oblique muscle, which is certainly the most important active defender of the inguinal canal and the external oblique aponeurosis, which has a very important role in supporting the layers beneath.
I would like to underline the importance of *the inguinal triangle* as a weak *passive area*. It is often wide and unprotected by the shutter mechanism. Concluding, I would like to point out that *narrowing a passive area means reinforcing it.*
According to what has been pointed out, the purposes of a "functional" hernial therapy is:
- repair of the lacking *sealing function* of the posterior layer
- repair of the lacking sphincter effect at the level of the deep ring
- repair of the lacking shutter mechanism.

Repair of the seal function of the posterior layer

It is very important to separate the elements of the funiculus from the proximal tract of the cremaster, in order to eliminate even small adipoceles, because they stick to the cremaster and easily lead to recurrences. A perfect calibration of the deep ring around the cord elements is no less important.
Anyway, one must consider that even after a good repair has been performed, the poor quality of the tissues surrounding the ring, make the risk of laceration greater.
Repair of the posterior wall of the inguinal canal is fundamental in direct hernia. In this case, sometimes the stitches passing through an entire wall, may cut the tissues and open new hernial defects.

Repair of the sphincter effect at deep ring level

The action (narrowing and rising the deep ring so that it be protected by the internal oblique muscle) of the transversus muscle may be repaired as long as the deep ring remains on the same anatomical

level, free *and independent* from the levels above.

Repair of the shutter mechanism

In order to repair the shutter mechanism, the inguinal canal must be narrowed and must *border on the entire inferior-lateral side* of the internal oblique muscle. This means that if the lower lateral margin of the internal oblique muscle is short and it inserts high on the rectus sheath, the inguinal canal has to be short and end at the same height of the rectus sheath.

The inguinal triangle has, therefore, to be excluded from the inguinal canal. Like every other passive area, it has to be reinforced and narrowed, compatibly with a moderate tension of the sutures.

These premises are necessary to explain the technical choices of the physiological hernioplasty. Its purpose is to repair the defense mechanisms of the inguinal region respecting the principles of physics and biology.

The myopectineal orifice

According to Fruchaud, the myopectineal orifice is bordered, medially by the rectus sheath, superiorly by the transversus and internal oblique muscles, laterally by the iliopsoas muscle, inferiorly by the pubis covered by the Cooper ligament and by the pectineus muscle with its fascia. Basically, this perspective believes that the two weak areas of the inguinal and crural regions are essentially one. The iliopubic tract and the inguinal ligament, which cross and divide the myopectineal orifice, are considered supporting elements of minor importance.

This position has been supported by those who advocate suturing or better still insertion of meshes into the entire weak area corresponding to the myopectineal orifice. Reality has belied this perspective: crural hernia is far less frequent than inguinal hernia. Evidently, the iliopubic tract and the inguinal ligament have very important roles as "support beams", also because they occur in an angular area, so that, according to Laplace's law, the stress is reduced due to the existence of a short bend radius.

I believe it is better to limit the surgical trauma. Too often supporters are overenthusiastic about the "myopectineal orifice" and this leads to the practice of ample dissections and applications of meshes anchored to the Cooper ligament without any specific indication.

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7 WHY A NEW METHOD?

Traditional methods tend to repair normal anatomy, without respecting the physiology of the area. It is well-known that sutures under tension or which go through the whole wall can open new hernial defects, create ischemia and impede perfect healing. Recurrences exceed widely the 10% in patients not treated in specific hernia units.

Meshes substitute and reinforce tissues, avoid suture tension, but they do not eliminate passive areas. Physiology of the inguinal region is hardly ever respected even in prosthetic surgery. Recurrences are definitely reduced with meshes compared to traditional methods. But even if mesh technique is expanding today, direct suture still remains the most common.

Today, some prosthetic methods have a recurrence incidence of close to 0%. Is there any possibility for further progress? Is there any necessity for a "*post mesh*"?

I usually use mesh and think, that in many cases they are useful and in some absolutely necessary. But, I do not believe they should be used indiscriminately. Even if their side effects are rare, when they arise they can be serious. Even if the main objective, that is recurrence, is avoided; patients, as they often refer, may have an unpleasant subjective perception of the prosthesis after recovery. I would also like to remark, even if a foreign body is biocompatible, it is always artificial and unnatural.

That is why I propose a technique, which is not a return to the past, but belongs to the "post mesh" era. I think the time has come to give its due weight to *physiology*, so often emphasized yet so often neglected. I also believe that the biology of tissue should be more respected. *Biology* is not respected

by substituting tissues with foreign inert bodies, even if sutures are without tension.
Today, the repair of the defense mechanisms and respect of the biology of tissues can be harmonized.

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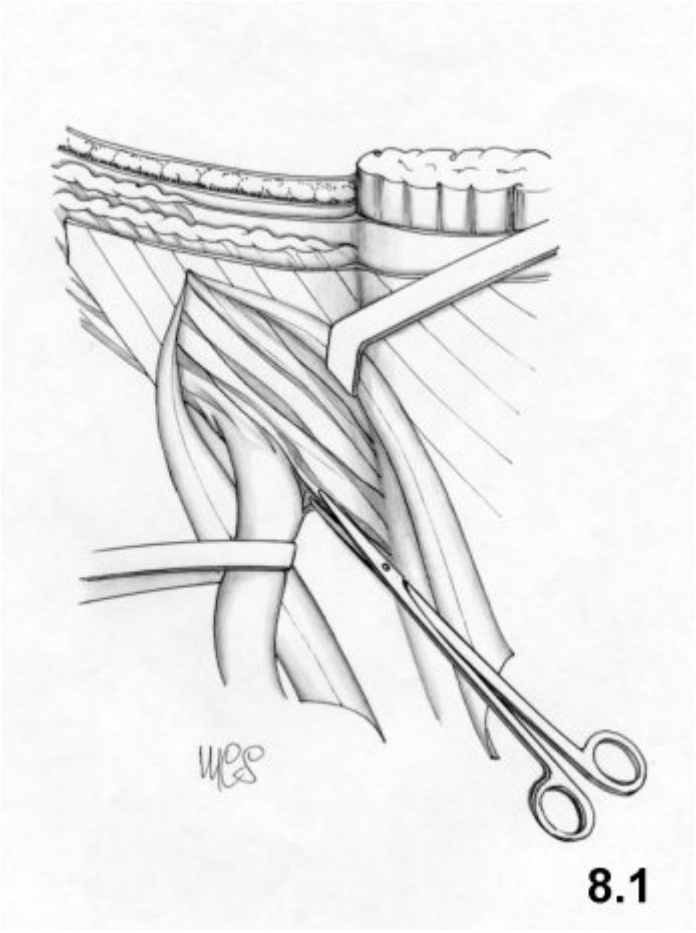
8 PHYSIOLOGICAL HERNIOPLASTY

To understand the principles and objectives of my inguinal hernia surgical repair technique it is sufficient to refer back to chapter 6.
My technique was devised in 1988 for two purposes:
- restoration of the defense mechanisms of the inguinal region through repair which adapts the anatomy to functional necessity.
- respect of the biology of sutured tissues.
These two objectives always considered of major importance, have never been simultaneously achieved by traditional or modern methods.

The technique

Common preliminary steps

- The best skin incision is transversal, because it heals better.
- The cribriform fascia is cut slightly below the inguinal ligament to free the external oblique aponeurosis on the lateral side and to check for the presence of a subclinical crural hernia.
- The external oblique aponeurosis is incisedfg along the fibers as far as the opening of the superficial ring.
- The medial flap of the external oblique aponeurosis is dissociated from the layer below. The separation should be quite wide in order to uncover the rectus sheath as much as possible.
- The funiculus is isolated at the level of the pubic spine and pulled laterally.
- The inferior border of the internal oblique muscle is separated from the medial fibers of the cremaster (Fig. 8.1).
- The cleavage between internal oblique muscle and aponeurotic arch of the transversus muscle is detected. The internal oblique muscle is retracted medially and the layer constituted by the aponeurosis of the transversus and transversalis fascia is exposed medially to the deep ring, for a wide tract.

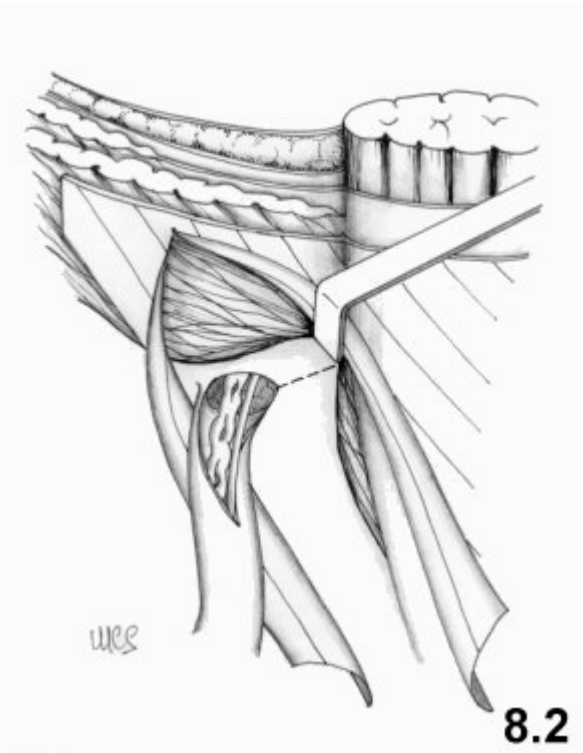


Treatment of the deep layers

The treatment of the deep layers is different in indirect hernia with a medium-small defect and in direct or indirect hernia with a large defect.

Indirect hernia with a medium-small defect.

- An incision on the funiculus involving the proximal tract of the internal spermatic fascia as far as the deep ring, is performed.
- The sac, beyond the neck, is isolated. It can be either resected or simply pushed in the preperitoneum. I prefer the second choice, unless the sac is very long and adherent. In this case, I divide it leave the fundus in situ.
- The elements of the funiculus (vessels and deferent) are separated from the proximal tract of the internal spermatic fascia and cremaster and then isolated. The isolation is extended to the level of the deep ring and, for a few centimeters, in the preperitoneal area.
- A two-centimeter incision is performed on the transversalis fascia and aponeurosis of the transversus, starting on the deep ring, in a medial and cranial direction (Fig. 8.2).
- The elements of the funiculus are brought to the medial angle of this incision (Fig. 8.3); then, the first layer of suture is started. With the first passage of the thread, a new easily calibrated deep ring is created (Fig. 8.4). The incision is then sutured until the original ring is completely closed (Fig. 8.5). Keeping the same suture, a second layer is created, but in the opposite direction, to cover the first layer with the cremaster and internal spermatic fascia. (Figs. 8.5, 8.6).



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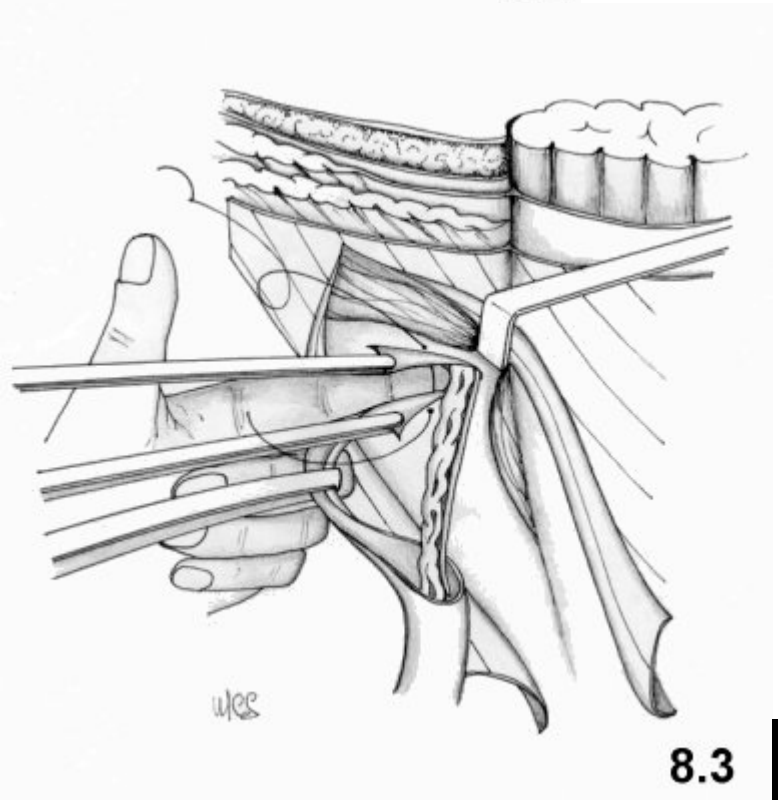

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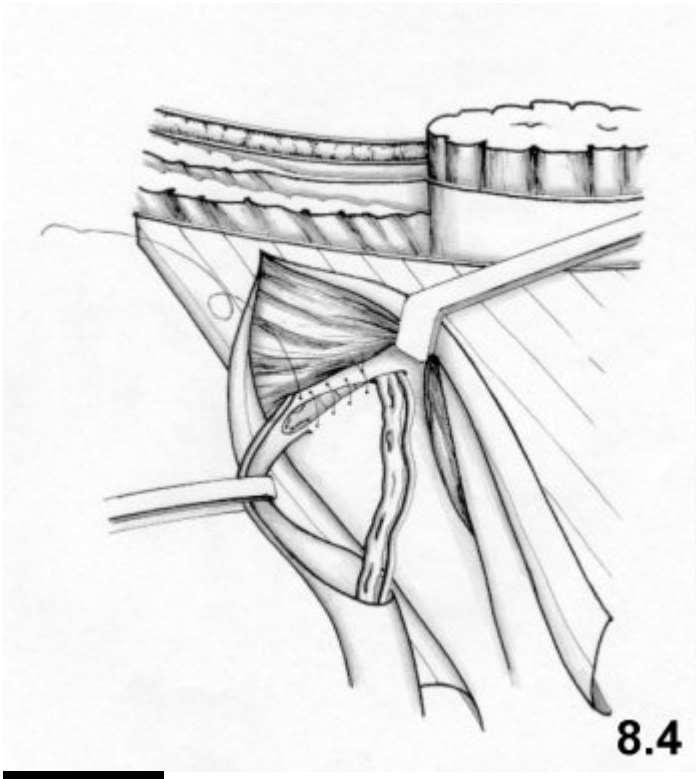

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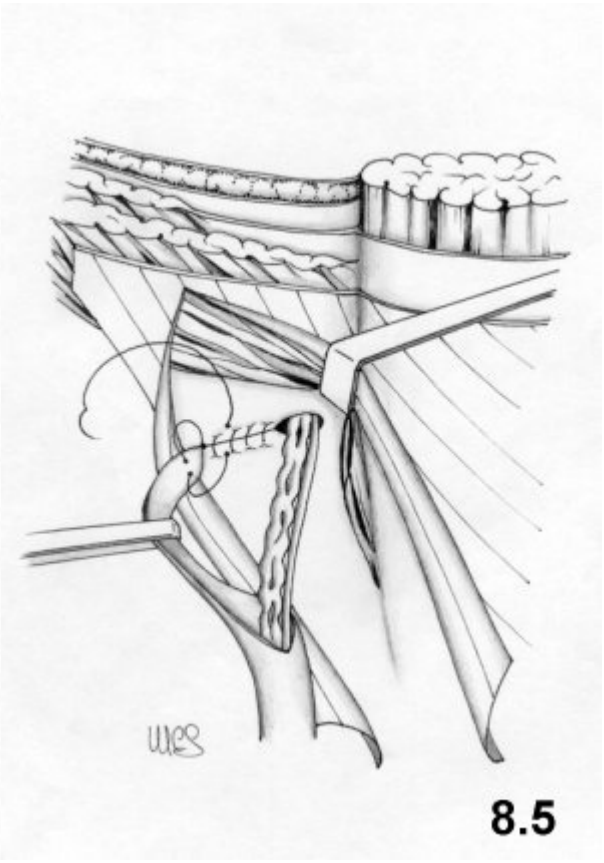

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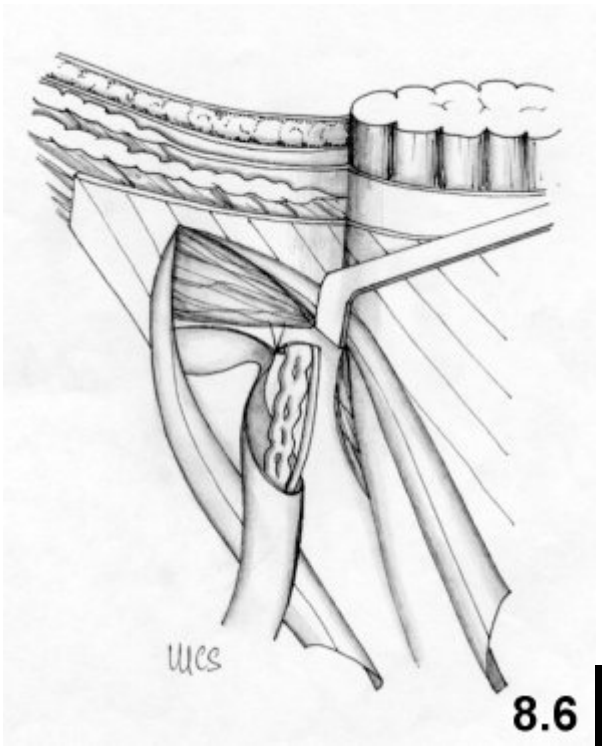

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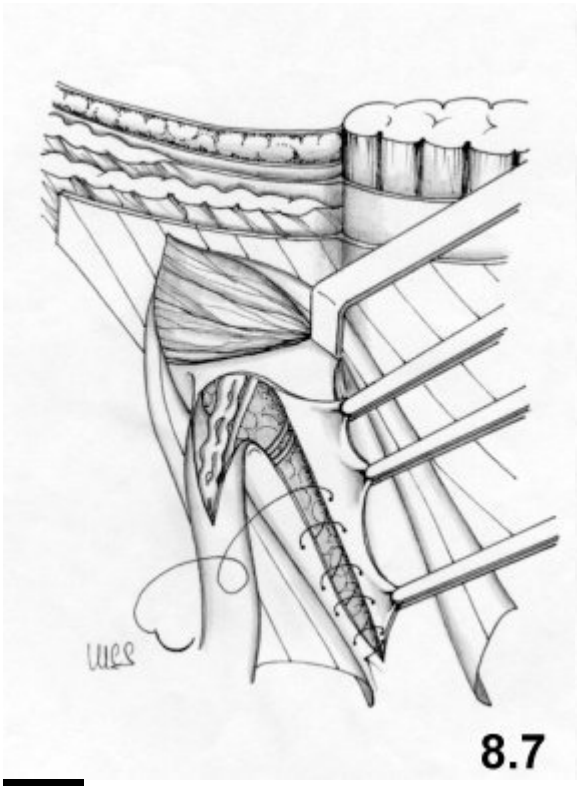
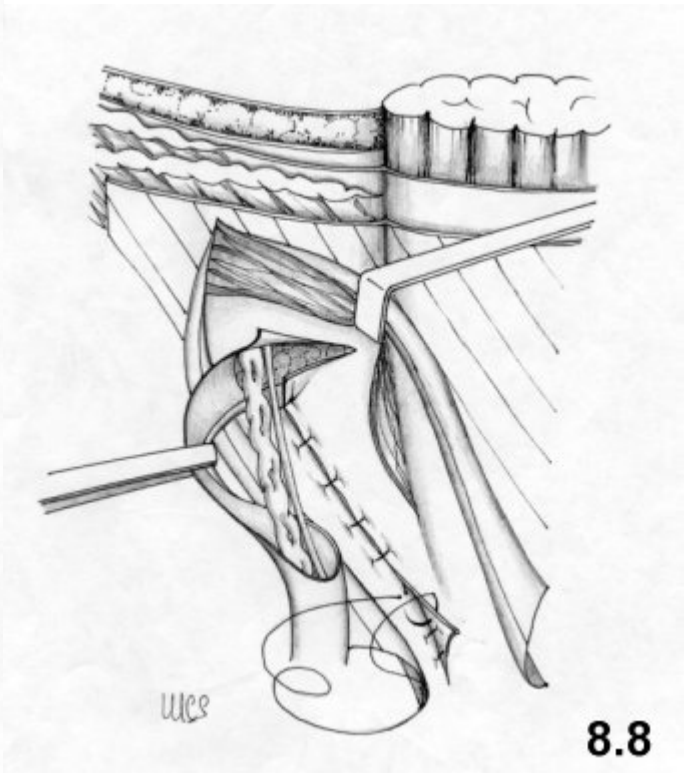
Direct hernia or indirect hernia with a large defect.

My technique consists in partially repairing the posterior wall of the inguinal canal so as to transform the large defect into a small-defect indirect one. The surgery is then completed following the repair

technique for a small-defect external oblique hernia.
The common preliminary procedure has already been described.
Having isolated the funiculus and retracted the internal oblique muscle the rest of the operation will follow a precise pattern depending on the nature of the hernia.
In indirect hernia, a medial incision is performed, which involves the proximal tract of the internal spermatic fascia and the deep ring. A second incision on the transversalis fascia of the deep ring up to the pubic spine is performed.
In direct hernia, the transversalis fascia above the hernial sac is resected. Then, an incision on the transversalis fascia is extended cranially, up to the deep ring.
The sac, both in direct and indirect hernias, is isolated beyond the neck, and simply pushed into the preperitoneal cavity. Only in big scrotal hernias, the sac is resected leaving the body and fundus in situ.

- The preperitoneum is detached from the transversalis fascia medially to the hernial defect, beyond the lateral margin of the rectus sheath.
- The posterior wall of the inguinal canal is partially closed through overlapping of the flaps with a continuous suture. The suture joins the iliopubic tract to the internal surface of the transversalis fascia at the level of the lateral margin of the rectus muscle (Fig. 8.7). It starts at the pubic spine and stops at the level of the inferior epigastric vessels. The left-over medial flap of the transversalis fascia is joined, using the same continuous suture, to the iliopubic tract. (Fig. 8.8). The suture does not involve the inguinal ligament and only touches lightly, the deep ring, which is left open.
- Then one proceeds as if dealing with an indirect hernia with a medium-small defect: the internal oblique muscle is retracted and an approximately 2-centimeter incision with a medial direction is performed on the transversalis fascia beginning from the deep ring (Fig. 8.8).
- The elements of the funiculus are separated from the internal spermatic fascia + cremaster and dislocated to the medial angle of this incision. A continuous suture creates a deep neo-ring, unites the borders of the incision and, after the deep primitive ring has been completely closed, on the way back, covers the suture line with the cremaster. (These surgical manoeuvres have been described in details; cf Figs. 8.3, 8.4, 8.5, 8.6).
- In cases in which the posterior wall of the inguinal canal is wide and strong, instead of repairing with overlaying flap, a plication of the transversalis is carried out to narrow the inguinal canal: a continuous suture joins the iliopubic tract to the aponeurotic arch of the transversus, from the deep ring to the pubis.

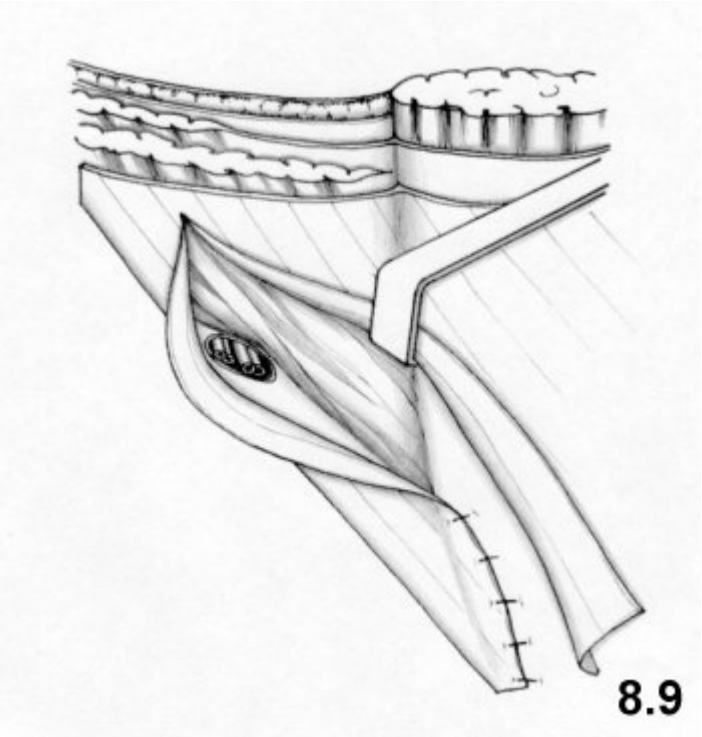




Treatment of the superficial layer

The repair of the superficial layer is the same as in all hernias.

- The external side of the inferior-lateral border of the external oblique aponeurosis is freed completely from every adhesion.
- The point at which the inferior part of the internal oblique muscle reaches the rectus sheath is found. At this level a new superficial ring is created: the suture is performed between the margin of the inferior-lateral flap of the external oblique aponeurosis and the rectus sheath, along a line parallel and 1 cm medially from the lateral margin of the rectus muscle. The suture runs up to the pubis (Fig. 8.9), while the funiculus is kept laterally to the operation field. Therefore, the suture is behind the funiculus. Usually, we use continuous suture in both directions, so that it is easier to tie the thread.
- The funiculus is relocated in its place, leaning completely on the internal oblique muscle.
- Enough space is left for the exit of the funiculus (Fig.8.10), and a second suture between the rectus muscle sheath and the lateral margin of the external oblique aponeurosis, along the previous line, is performed. The third suture level is, therefore, completed.
- The fourth layer is characterized by the suture which involving the superior-medial flap of the external oblique aponeurosis and the external side of the inferior-lateral aponeurotic flap, so that there is wide overlapping without much tension. This suture level, as the previous one, is antefunicular and proceeds from the neo- superficial ring to the cranial extreme of the incision (Fig. 8.11) and retrofunicular from the superficial neo-orifice to the pubis (Fig. 8.12).



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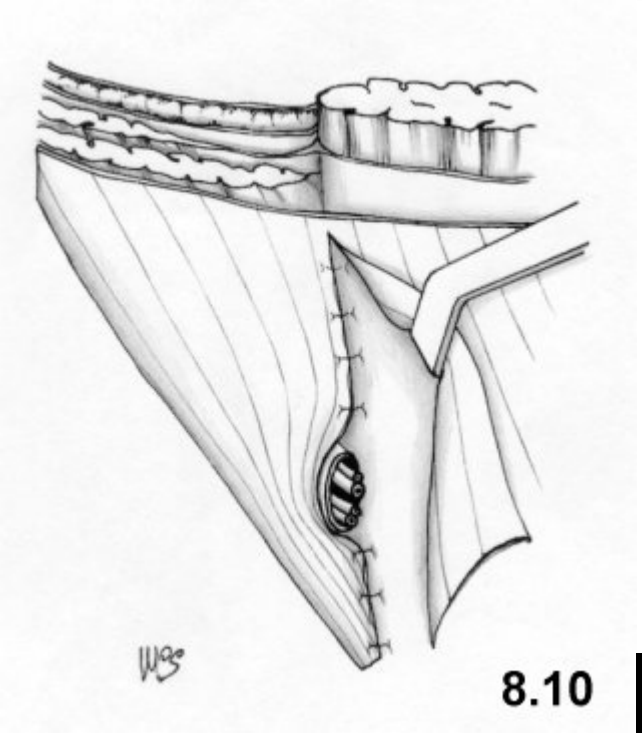

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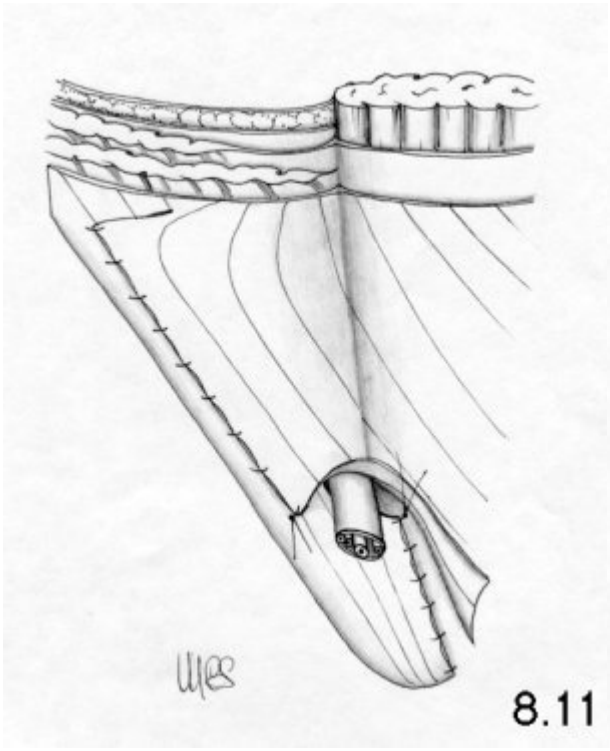
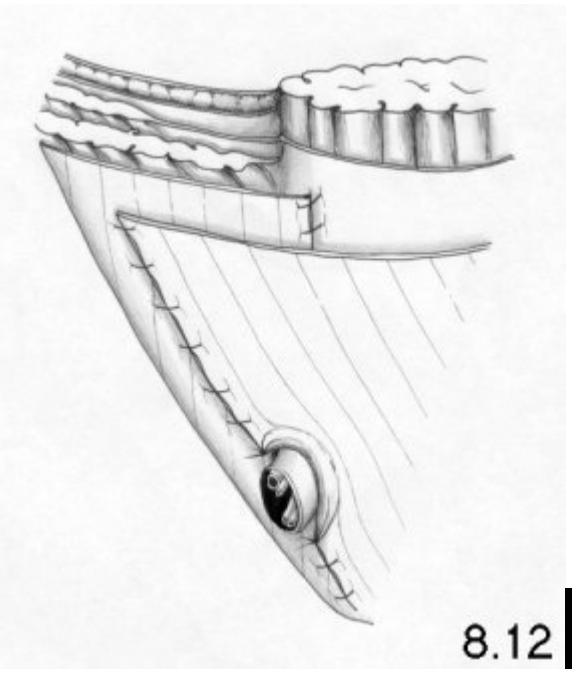




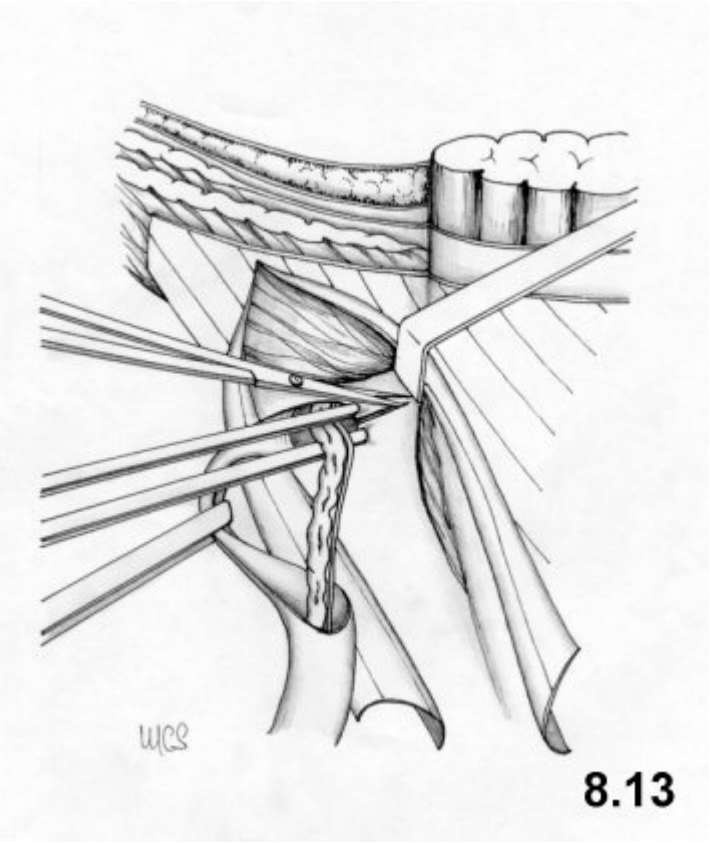
In case of the poor-quality tissue, this technique may include the use of mesh.

The suture materials

We use absorbable sutures (polyglicolic acid) and nonabsorbable sutures (polypropylene). The latter only in cases in which polypropylene mesh are used.

The main technical details

Isolation of the funicular elements from the proximal tract of the cremaster
After having opened the internal spermatic fascia, the isolation of the vessels is very easy. The deferent duct is more adherent to the surrounding tissues, but easily recognizable because of its consistency. Usually it is possible to see the peritoneal reflection stuck to the elements of the funiculus. We dissociate it for a few centimeters to avoid its passing into the deep ring which might lead to a hernia recurrence. It is necessary to resect any adipoceles, even the small ones, frequently located on the internal side of the cremaster.
Exposition of the layer: transversalis fascia + aponeurosis of the transversus muscle
After isolating the hernial sac, two Kelly forceps are put on the medial border on the deep inguinal ring, next to the preperitoneal fat, and also a light upward traction is performed. With a Russian forceps, the adipose tissue below is pinched and pushed inwards. In this way, the separation of the layers becomes easy. The transversalis fascia can be well detected at deep level. The Kelly forceps are placed on it with a light traction. With the Russian forceps itself, held closed and used as a spatula, the fibers of the internal oblique muscle are easily separated from the level below. Then, they are pulled back medially, in order to uncover widely the transversus arch.
Incision of the transversalis fascia and creation of new deep ring
As said, two Kelly forceps are placed on the border of the transversalis fascia at the level of the deep ring. The caudal forceps is removed, passed below the funicular elements and reattached at the same spot. The fascia is kept in traction with the forceps and incised with the scissors (Fig. 8.13).



At this point, the traction applied to the internal oblique muscle should be high to better expose the operation field. A two-centimeter medial incision is performed. If the internal oblique muscle is poor, the incision is directed more cranially, so that the new ring can be covered by the muscle when the retractor is removed. The funicular elements are dislocated at the inner angle of the cut and pulled medially.
The two Kelly forceps are put close and pulled with the left hand, with the palm upwards.
The borders of the incision have to be very close. The index finger of the same hand, introduced in the preperitoneal space, pushes the funicular elements on the medial border of the incision. In this position, the first stitch of the continuous suture is performed (Fig. 8.3), then tied to give the correct calibration to the ring.

Closure of the deep ring

The continuous suture is brought about from the neo-ring to the deep ring. Once the deep ring has been reached, the suture runs along the external hemicircumference. The inguinal ligament, which is close to the lateral edge of the deep ring, should not be included in the suture. The ring will be easily closed from the traction of thread. The same suture, on the way back, joins the free part of the cremaster to the suture line below.

Verification of the ring caliber

The right caliber of the deep neo-ring and of the superficial neo-ring are verified introducing in them a curved Kelly forceps. The deep ring has to be neither too narrow nor loosen. The new superficial ring has to be rather wide. If it is too narrow, it could be widen with a short transversal incision on the external oblique aponeurosis.

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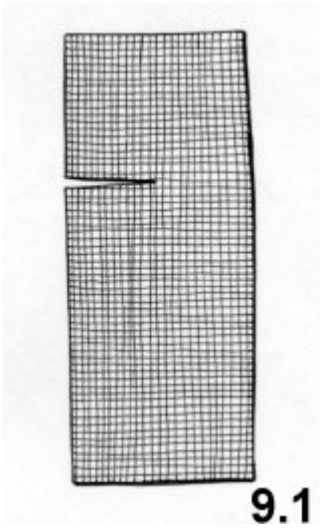
9 THE USE OF MESHES

Meshes are a great progress in hernia surgery and may be useful in some cases, in others indispensable. I do not think, however, that meshes such be used merely on principle.
In small hernia defects, when the tissue is weak, they should be used to reinforce sutures and tissues as to perform a "barrier- function□, while the defect must always be sutured. Only in large

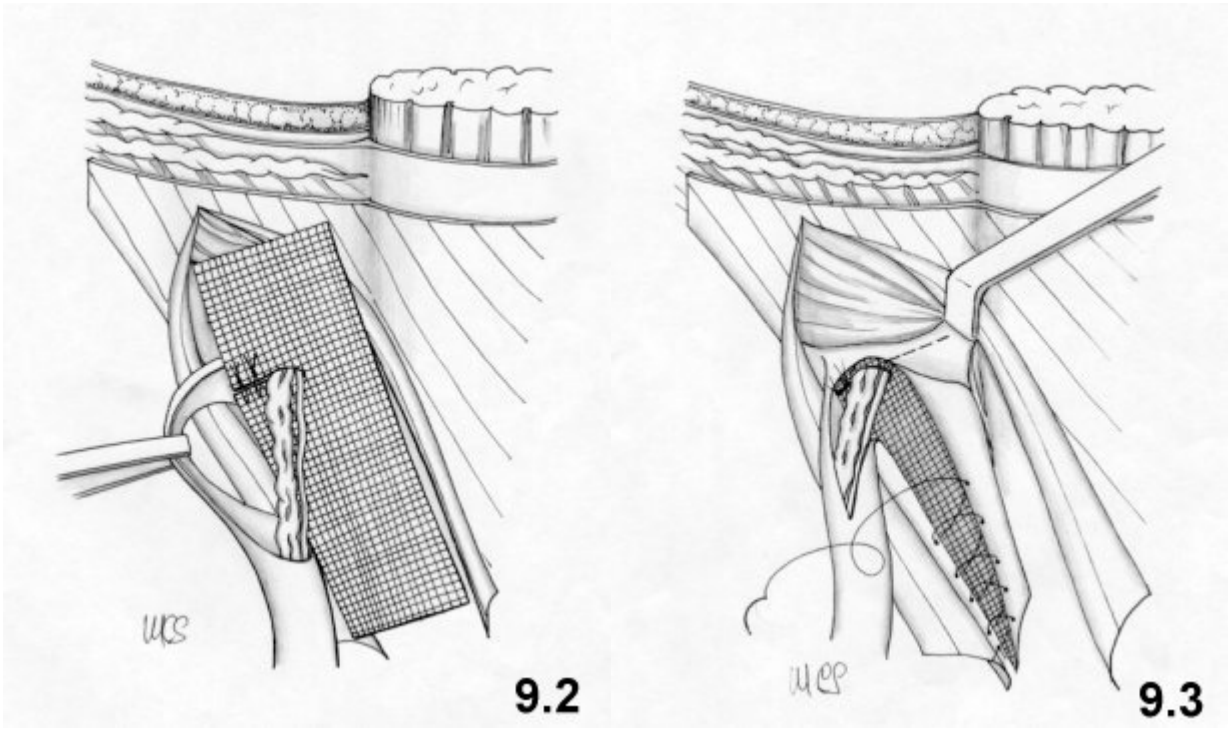
defects, the mesh substitutes tissue. The priority is reduction of passive areas rather than concern about suture traction. Under strain and in a standing position tension on the suture is inevitably provoked. Furthermore, endoabdominal pressure creates stress in the passive areas, in proportion to their size.
In primary hernias, if the tissues are very weak, inelastic and lacking in quantity, we use meshes to reinforce the hernioplasty. This occurs in 5% of primary hernia cases. The mesh is positioned in the preperitoneum or alternately in front of the posterior wall of the inguinal canal and of the deep ring, once it has been closed. Mesh may also be used for prudential reasons when the surgeon is not very familiar with the physiological hernioplasty technique.
We use mesh on principle in crural hernias and in recurrences. In this case, we try to close (successfully in most cases) or, in any case, to narrow the hernial defect as far as possible.
In crural and recurrent hernias meshes are always used and positioned in the preperitoneum.

The use of preperitoneal meshes in primary hernias

The procedure is identical to that already described for direct or indirect hernias up to the step where the sac is isolated. The funicular elements are separated and well isolated from the cremaster + internal spermatic fascia.
A rectangular polypropylene mesh, of about 4 x 8 cm is used.
A cut of about 2 cm, is made at 1-2 centimeter from the midpoint, perpendicular to one of the longer sides of the mesh. (Fig. 9.1).



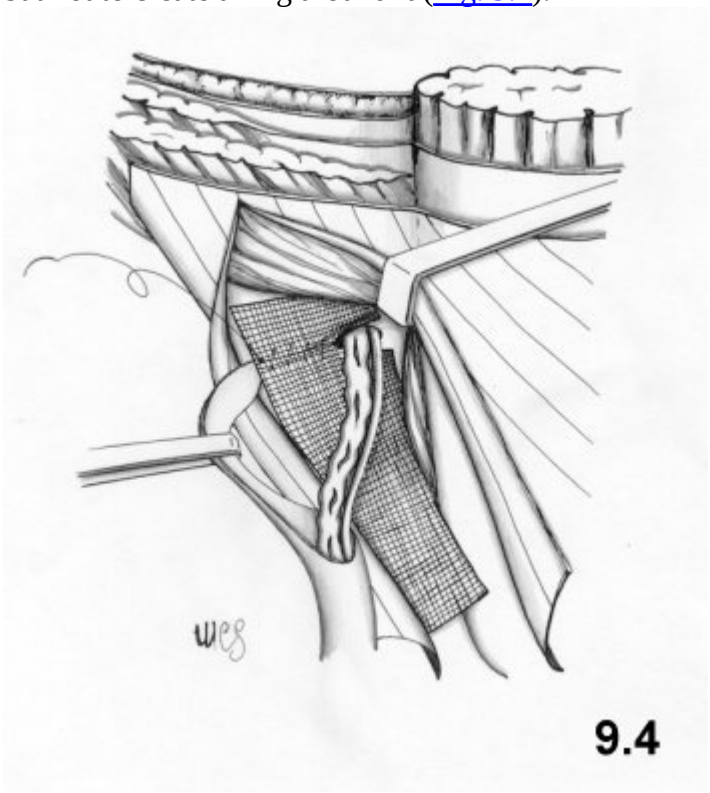
The mesh is oriented with the cut side towards the surgeon and the shorter tract in a cranial position. The cord elements are inserted in the cut, which is then transformed into an eyelet with 1-2 polypropylene stitches. (Fig. 9.2).
In the indirect hernia, the mesh is placed in the preperitoneal area through the incision of the transversalis fascia made to create the neo-deep ring. The mesh is then, fixed to the wall, including it in the suture of the transversalis fascia.
In large hernias or in direct hernias, the mesh is passed into the preperitoneal area through the wide incision performed on the posterior wall of the inguinal canal. During the repair phase, we usually fix the mesh to the wall, including it in the suture. (Fig. 9.3).



In both cases, the operation is performed following the same technique, as if the mesh were not used.

The use of meshes in the prefascial area in primary hernia

In the indirect hernia, when the transversalis fascia is weak or inelastic and the closure of the deep ring appears unreliable, a polypropylene mesh of about 2 x 6 cm is used on the posterior wall of the inguinal canal.
The mesh is positioned after the deep ring is closed. A short cut is made on the medial side of the mesh at the height of the neo-deep ring. This cut has the function to allow the passing of the funiculus but not to create a ring around it (Fig. 9.4).

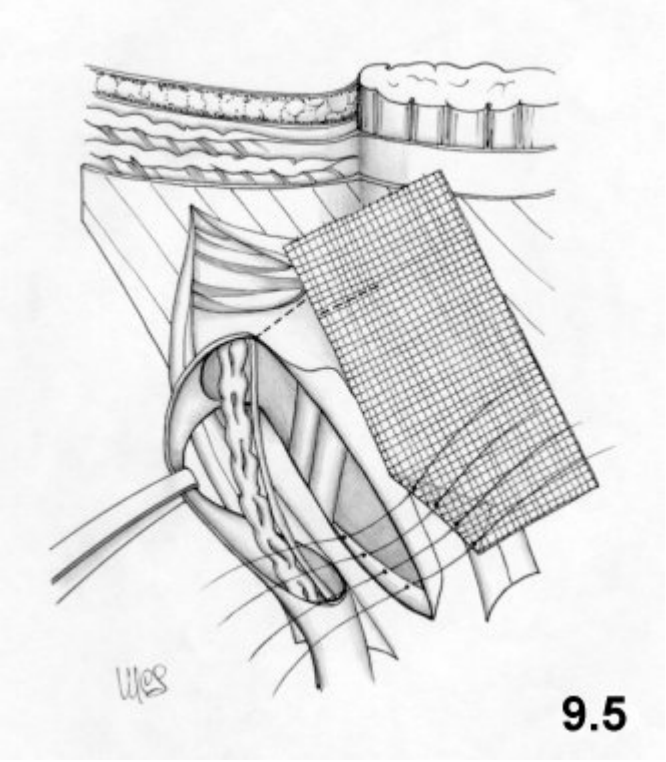


The thread used for suture, with which the deep ring has been closed, is posterior to and outside of the

mesh. With the same thread, backwards, the proximal flap of the cremaster is placed on the mesh, including in the suture also the transversalis fascia.
The mesh is then spread along the posterior wall of the inguinal canal. The parts of the mesh that exceed the medial and cranial sides, are to be positioned under and not anterior to the internal oblique muscle.
Other anchoring stitches are not necessary. Then, the repair of the overlapping flaps of the external oblique aponeurosis is performed.

The use of meshes in large inguinal and crural hernias

Our approach is usually inguinal. We reach the preperitoneum and the Cooper ligament, once the posterior wall of the inguinal canal has been opened.
The polypropylene mesh has a rectangular shape, of about 6-8 cm x 10-12 cm. The inferior-lateral angle of the mesh is folded so that length and inclination of the edge of the lapover fits the Cooper ligament and so that long side of the mesh is parallel to the axis of the groin.
A set of separate suture stitches is passed through the Cooper ligament and the mesh, at the level of the folded area.
Three- four stitches of monofilament polypropylene begin from the pubis and proceed laterally along the Cooper ligament, almost as far as the femoral vein. (Fig. 9.5).



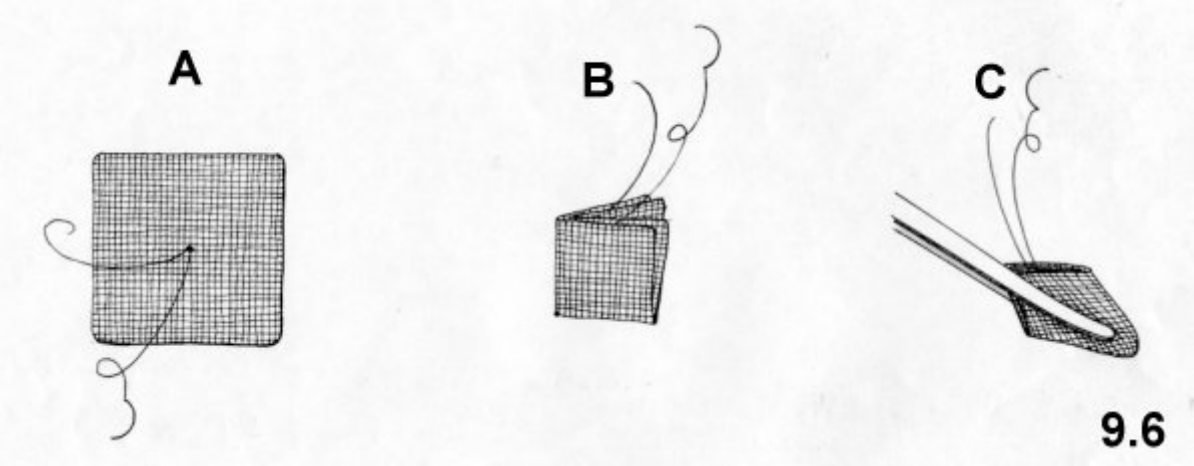
The suture on the Cooper ligament is performed more easily if the surgeon moves on the other side of the operation field.
The mesh is passed loosely in front of the femoral vessels so that the femoral vein does not undergo compression, even when it is swollen as in the standing position. A suture unites the mesh to the iliopubic tract and to the deep border of the inguinal ligament.
Before the suture has been completed, the funicular elements are passed through an eyelet created on the mesh.
The mesh is laid in the preperitoneal area.
The further steps depend on the conditions encountered. In most primary hernias, hernioplasty can be performed as described for direct hernia, anchoring the mesh in the suture of the deep layer.
In the recurrence, if necessary, the mesh is sutured to the transversalis fascia corresponding to the posterior wall of the rectus muscle. The stitches are positioned parallel to the mesh and 1-2 cm away from medial border. As far as possible the wall is repaired; in any case the aim is to narrow the opening as much as possible and cover the mesh with the upper layers.

The use of meshes in crural hernias

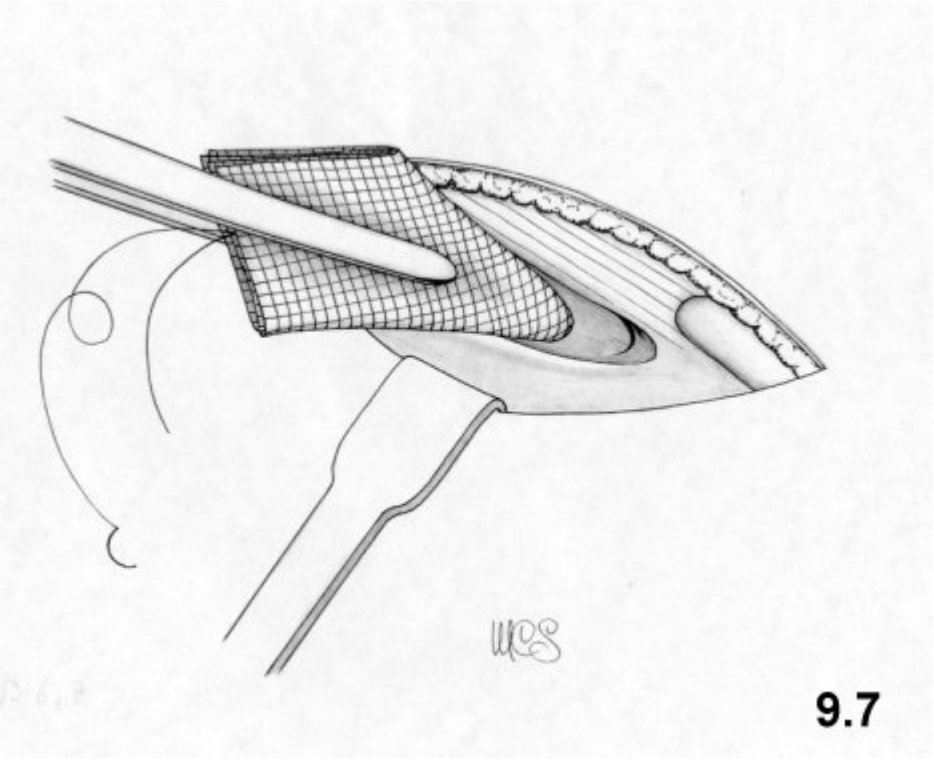
Large crural hernias are repaired anchoring the mesh to the Cooper ligament with the above-mentioned technique.
The anterior approach in the crural hernia is simple, but we cannot obtain a good repair directly suturing the hernial defect. The Cooper ligament and the transversalis fascia are very difficult to reach through a small hernial defect. Then, the lack of tissues and their stiffness do not allow the performance of a good suture. Therefore, the use of mesh is necessary.
I have developed a technique, called "*Locked -Plug*". It is very easy to perform and it permits us to treat crural hernias having a small diameter (1-2 cm) with anterior approach. This technique can be also used to treat subclinical crural hernias, found during an operation for inguinal hernia. In this case, the crural hernia is repaired independently from the repair for inguinal hernia.

The "Locked-Plug" technique

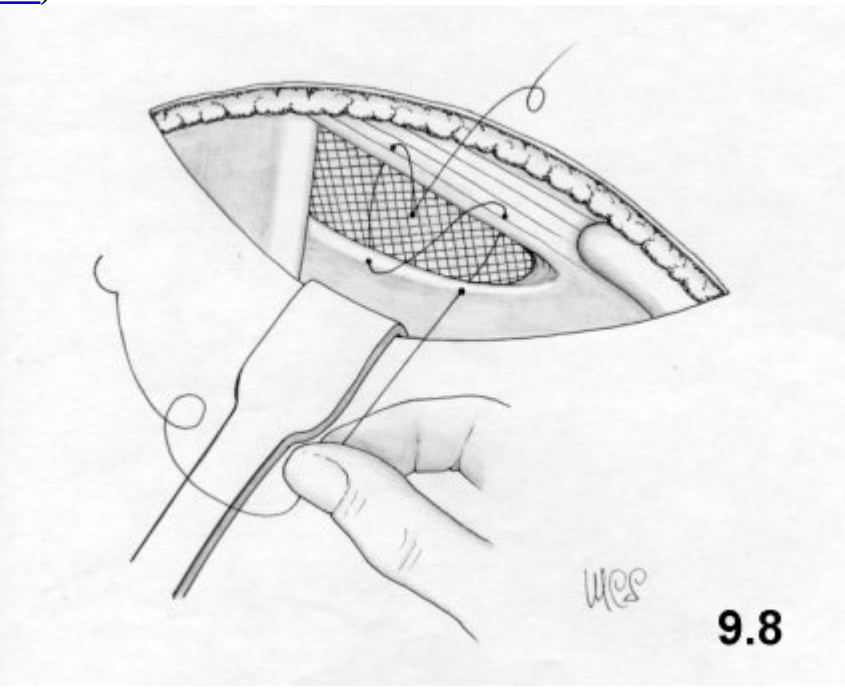
The approach is anterior. Once the cribriform fascia has been opened, the hernial sac is reached, reduced or resected.
It is important to detach the sac itself from the hernial defect. A polypropylene square of 4 x 4 cm is cut. A thread of monofilament polypropylene is passed through the central point of the square and tied. The end of the thread (the part beyond the knot) is left 10 cm long and is not cut.
The square-shaped mesh is folded twice along the orthogonal lines, crossing the center (Fig. 9.6), so that the thread remains in the inside.



Then, the mesh is bent diagonally to give it a cone-shape, in which the tip corresponds to the midpoint. The "cone" is then held firm with a curved Kelly forceps and introduced in the hernial defect (Fig. 9.7).



When the forceps is removed, the cone spontaneously tends to expand, helped by the forceps re-introduced into the defect, while a slight traction is applied on the thread.
The same thread is used to suture the borders of the hernial defect. Two stitches are sufficient (Fig. 9.8).



A traction on the tract of the thread linked to the needle narrows the defect and fixes the mesh on it. The two ends of the thread are, then, tied together.
It is not necessary to include the Cooper ligament and the iliopubic tract in the suture, which cannot be reached through the small defect. It is sufficient to suture the inguinal ligament to the pectineus fascia, which are easily joined.
The purpose of the operation is to narrow the outlet of the canal and plug it with a well-anchored mesh. The holes made by the stitches are protected from the mesh itself, even if they were too wide.
Tension of the suture is minimal
The procedure is easy and secure: the suture is limited to only the central area of the hernial defect, at a secure distance from the femoral vein.

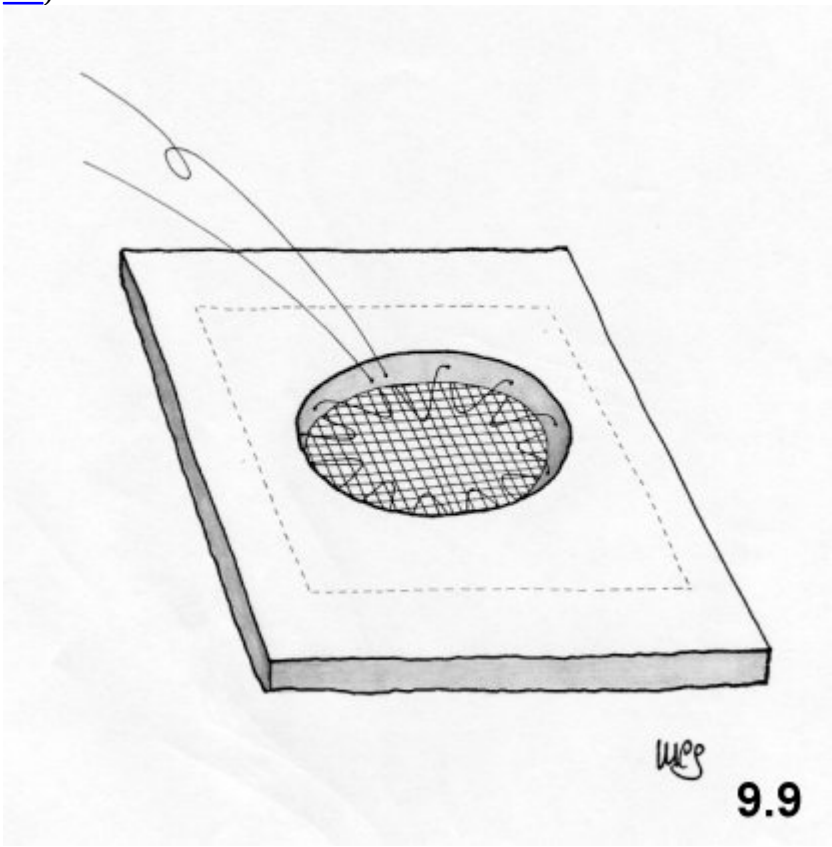
The use of meshes in inguinal recurrences

The treatment of recurrence requires great specific surgical experience, not only in the repair, but also in the dissection phases and in the preparation of the layers and of the spermatic cord.
In the past years, we have chosen to minimize dissection and results have proven us to be right. We have limited dissection only to the preparation of the sac and the hernial defect, and in indirect hernias, to the funiculus. If hernias are multiple and well separated, we treat each separately.
This repair always requires the use of mesh.
We use different repair techniques depending on whether we are dealing with:

- direct hernia with a small defect
- direct hernia with a medium defect
- indirect hernia
- hernia with a big defect

Direct recurrent hernia with a small defect (up to 1 cm in diameter)
As in crural hernias, this repair is performed with the *Locked-Plug* technique.

Direct recurrent hernia with a medium defect (1-3 cm in diameter)
Once the sac has been pushed into the peritoneal cavity and the defect is freed from tissue adhesions, a mesh bigger than the hernia defect is positioned in the preperitoneum. A continuous suture joins the mesh to the lower part of the wall, without passing through its entire depth. The suture then runs along the border of the hernial defect, describing a circle having a smaller diameter on the mesh. (Fig. 9.9).



Once the suture has been completed, the thread is pulled and tied up. This round suture fixes the mesh and narrows the hernial defect while at the same time avoids that the preperitoneal fat enters between the mesh and the wall.
Then, another suture joins the edges of the hernial defect. This suture is carried out only when there is no excessive traction and includes only the superficial level of the wall.

Indirect recurrent hernia with a small - medium defect (1-3 cm in diameter)

In indirect hernias, once the hernial defect and the funiculus have been prepared, a mesh bigger than the hernial defect is prepared.
The spermatic cord is passed through the mesh through a 2-cm cut and a suture is performed, so that a calibrated ring is formed.
The mesh is introduced in the preperitoneum through the hernial defect.
If the defect is small, it can be sutured directly, calibrated on the spermatic cord and the mesh included in the suture.
If the defect is medium size, a circular suture between mesh and wall is performed, as described for direct hernia. In this case, if there is not much tension, the hernial defect is sutured and calibrated on the funiculus.

Hernia recurrence with a large defect (more than 3 cm in diameter)
Fortunately, hernia recurrences with large defects, associated with lack and stiffness of the tissues, are very rare. In this case, it is impossible to standardize a procedure: it requires surgical experience and ability. If the surgeon is not familiar with the preperitoneal approach, it is better to anchor the prosthesis to the Cooper ligament as described above. The mesh must be considerably larger than the hernial defect. Therefore, a wide dissection of the peritoneum and the ligation of the inferior epigastric vessels are necessary.

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10 CASES AND RESULTS

Francesco Guarnieri

From December 1988 to June 1999, we operated on 2,326 patients for inguinal and crural hernia: 1,246 for indirect hernia, 470 for direct hernia, 335 for double hernia, 226 for recurrent hernia, 49 for femoral hernia. During these operations 47 subclinical femoral hernias (2%) have been found. 2,162 were males, 164 were females; the average age was 56 years (min. 1, max 98).
Local anesthesia was used on 1,710 patients (74 %), general anesthesia on 421 patients, spinal anesthesia on 195 patients (8%). The choice of the type of anesthesia performed was decided together with the patient.

Primary direct and indirect hernias

From the onset, physiologic hernioplastic technique has been applied in 2,051 operations. This technique has undergone a series of marginal technical variations over time. The most significant change has been the percentage variation in use of mesh as a reinforcement in hernioplasty. Up to January 1998, when meshes were used, these were positioned in the preperitoneal space only. Subsequently prefascial meshes were also employed.
During the first year, meshes were used in 49% of all cases. This high percentage was linked to the fact that we were not as yet certain of the efficacy of the new technique. As the results grew increasingly encouraging, we started to reduce the use of meshes drastically. In the second year, we used meshes in 50% of those cases we considered as being high risk due to poor tissue quality. Since no significant incidence of recurrence occurred, the use of meshes was gradually reduced to 8% in 1991. The decision whether to use meshes is usually made in the operating theatre, where the quality of the tissues can be evaluated.
Another important variation is the execution of incisions to relax the rectus sheath, which technique we eliminated in February 1996, having verified through ultrasound and CAT that no significant widening of the rectus muscle occurred.
Today, we use the relaxing incision of the rectus sheath in those extremely rare cases when the rectus muscle is very narrow.

Recurrent hernias

Recurrent hernias belong to a heterogeneous group of cases, where physiologic hernioplasty is difficult to perform due to fibrosis. Moreover, in the last few years we have reduced dissection to a minimum.
As already stated, in recurrent hernias we always apply meshes.

The Locked-Plug

The locked-plug was not only used in crural hernias, but in other kinds of hernias where the defect always presents a diameter of less than 2cm. We have used it in 218 cases: 96 femoral, 57 recurrent, 30 umbilical and epigastric, 23 incisional, and 12 Spigelian hernias. We have treated 47 subclinical crural hernias, detected during surgery for inguinal hernia, with the locked plug.

Follow-up

Since December 1988, patients have been scheduled for follow-up after 7 days, 1 month, 1 year and then annually. Patients who have not followed follow-up programs have been excluded from this survey.

Primary hernias
Here we shall speak mainly about primary hernias, the technique has been applied systematically only in this ambit. Postoperative complications that arose were: 5% subcutaneous seroma, 1 % temporary testicular edema, 0.7 % hematomas, 0.4% wound infection, 0.1% testicular atrophy, 0.7 % recurrence. It should be noted that no recurrence occurred in those cases where meshes were employed.
In the first year, when the femoral ring was not systematically explored, 2 cases of crural pseudo-recurrence were found. After that no cases of pseudo-recurrence were observed. Subclinical crural hernia was found in 2% of patients operated for primary hernia.

Recurrent hernias
Complication incidence rates: 0.8 % wound infections, 14 % subcutaneous seroma, 2 % hematomas, 2% testicular edema, 1.5% testicular atrophy, 2.6% new recurrence.

LockedPlug
Complications: 6% subcutaneous seroma.
No recurrence.

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11 RATIONALE

My rationale is best understood in the light of Chapter 6. As stated there, this technique aims at restoring the architecture of the inguinal region, so that the defense mechanisms are repaired and the weak areas narrowed and reinforced.
The objective is not to restore the anatomy, but adapt it to functional needs, compensating for tissue weakness, while fully respecting the norms of physics and biology.
The characteristics of the technique are:

- elimination of the deep inguinal ring and creation of a neo-orifice.
- narrowing and shortening of the inguinal canal, tailored to fit the internal oblique muscle.
- overlap of the external oblique aponeurotic flaps.
- preservation of the cremaster

The elimination of the deep and construction of the new ring
In most cases the deep ring is surrounded by weak tissues, unable to resist suture strain. Its reconstruction usually proves quite untrustworthy. For this reason almost all herniorrhaphy techniques seek to reinforce the deep ring, and anchor it to the inguinal ligament, thus, immobilizing and stiffening and defunctionalizing it.
Besides, the deep ring is not clearly detectable unless the cremaster is cut. The tissue weakness, together with defunctionalization and approximate suture, are among the chief causes of recurrence. For this reason, we have chosen to create a neo-deep ring, which may be easily calibrated around the funicular elements, and positioned in a stronger zone where it can be protected by the internal oblique muscle. When the transversus muscle contracts, the neo-ring narrows and rises, because it is situated between the fibers of the aponeurotic arch. The sphincter effect is thus repaired.

The narrowing and shortening of the inguinal canal
As stated above, the shutter mechanism is obtained only when the inguinal canal is narrow and totally surrounded by the internal oblique muscle.
In hernia patients, the internal oblique muscle is almost always hypotrophic and reaches the rectus sheath "high relative to the pubic spine. The lower zone, unprotected by the muscle, is called the inguinal triangle (Fig. 6. 3, p. 41). The suture of the external oblique aponeurosis onto the rectus sheath is performed so that the inguinal triangle is excluded from the inguinal canal and reinforced (Fig. 8.9, p. 50). Consequently, the inguinal canal becomes shorter, but functional. The shutter mechanism is thus achieved also because the internal oblique muscle is not affected by stitching capable of limiting its movement.

Overlapping the external oblique aponeurotic flaps
The external oblique aponeurosis is elastic and pliable along the fibers transversal axis. By suturing the external aponeurotic flap to the rectus sheath, a narrowing of the inguinal canal and of the inguinal triangle characterized by a moderate degree of suture traction, is produced. The medial flap is brought to overlap the lateral one abundantly, producing a minimum amount of tension. This overlaying distributes the already moderate suture traction even more and creates an extensive and compact scar area, which prevents the external oblique aponeurosis from fraying. Consequently, this aponeurotic layer, as a veritable biological prosthesis, creates new compact scar tissue which reinforces the passive areas without tension of the sutures.
The greatest advantage is obtained at inguinal triangle level, a passive area where traditional methods frequently encounter recurrence. In the inguinal triangle, the lateral flap of the external oblique aponeurosis, without the intrusion of the funiculus, is placed directly on top of the transversalis fascia, with which it forms an adherent cicatricial plane. The medial flap of the aponeurosis is overlapped once more forming a second scar plane. Together, these create a strong wall, certainly no less strong that one produced by a mesh.

Preservation of the cremaster
According to this technique the proximal portion of the cremaster + the internal spermatic fascia, free from the funicular elements, are overlapped onto the suture on the transversalis fascia between the deep ring and neo-ring. The cremaster, besides reinforcing the suture, completely and securely occludes the deep ring and blocks any small lacerations which may arise at the passage of the stitches on the transversalis fascia below. Further below, the cremaster remains intact and protects the testicular vessels from risks of iatrogenic lesions in case of an operation for recurrence.
In addition, resection of the cremaster may lead to neuralgia of the genital nerve. The cremaster vessels also guarantee a collateral vascular bed in cases of testicular vessel lesions.

Discussion
On the basis of what we have stated several times above, this technique is highly efficient in repair of the functionality of the inguinal canal. Even if the sling mechanism of the deep ring is not restored, the results prove that the sealing function of the posterior wall, at neo-ring level, remains intact. In fact the hernia recurrences we have encountered after our technique have never occurred at neo- deep ring level.

As to narrowing of the posterior inguinal canal wall, until February 1996, we supported the idea of the rectus sheath relaxing incision and performed it systematically. We held that this relaxing incision served to expand the rectus muscle laterally and narrow the inguinal canal. We were not interested in reducing the suture tension between the external oblique aponeurosis and the rectus sheath, which we considered minimal. After systematic examinations availing of ultrasound and CAT scans we discovered that lateral expansion of the rectus muscle did not in fact occur. We therefore eliminated the relaxing incision, which choice produced no changes in either postoperative conditions or results. At the same time we paid greater attention to the question of freeing the lateral flap of the external oblique aponeurosis from the lateral fascial tissues to bring it closer to the rectus muscle.
The technique does not favor the formation of crural hernias. We registered 2 crural pseudo-recurrences among patients operated, in the first period, when the fossa ovalis was not as yet explored. Since we began systematically exploring the fossa and treating subclinical concomitant crural hernias (2% of the cases), no pseudo recurrence has arisen.
The problem of suture tension and the poor healing, (which worries the supporters of the "tension free" school of taught) need to be addressed.
In our method the suture lines include only a tiny quantity of tissue and are used solely to connect fascias (which do not devascularize); furthermore, they are not aligned, nor do they pass through the entire thickness of the wall, thus receiving protection from the upper and lower layers which act as a barrier. The suture lines on the external oblique aponeurosis are arranged in such a way as to re-distribute the already low tension. The overlaping of the flaps creates ample contact areas between surfaces developing a solid scar tissue, similar to that developed around the meshes. Outcome data accruing to primary hernia operations reveal that this technique has a low recurrence rate, the lowest for techniques not availing of prosthetic mesh. The recurrences encountered by us were all direct smalldefect hernias at either original deep ring level or immediately below it.
Postoperative complications such as suppuration, transitory testicular edema and testicular atrophy comply with most reports.
It is very difficult for any Author, however self-critical, to point out the disadvantages of his/her own method. As similar self-criticism is hardly credible, I shall here present a number of critical objections I have received in a series of questions and answers.

In your large hernia technique, does the hernia defect repair not resemble Shouldice□s?
This method and Shouldice□s are very different both theoretically and practically; they are similar only in the repair of the lower part of the inguinal floor in direct hernias. Above all, contrary to Shouldice□s repair, the first line of posterior suture always involves the posterior edge of the rectus muscle. Furthermore, the second line of stitches along the transversalis fascia does not involve the inguinal ligament.
In the Shouldice technique, the first suture line includes the rectus muscle only along the lower tract; along the upper tract, it includes the aponeurotic arch of the transversus because the distance between the rectus muscle and iliopubic tract increases considerably as the deep ring is approached.
Does excessive traction between the rectus muscle and the iliopubic tract not occur?The rectus muscle and the transversalis fascia are very flexible. Besides, the already moderate amount of suture tension existing is reduced by sutures above. Furthermore, it involves the tract between the lower epigastric vessels and the pubis where there is less distance between the edge of the muscle and the iliopubic tract.
The funiculus forms a Z-shaped path. Does this not affect the blood supply to the testicle?The sinuosity of the path of the vessels does not impede the blood flow. In fact, the incidence of transitory edema (2%) and testicular atrophy (0.1%) in males operated on for primary hernia is low and in keeping with authoritative reports.
Is the funiculus not too tight in the new inguinal canal, occupied, as it is now by the internal oblique muscle?When the muscle tissue is at rest, it is soft and compresses the small vessels only slightly, as per Laplace's law. The contraction of the muscle undoubtedly causes compression, but it is temporary and irrelevant. Besides, under normal conditions, the contraction of the internal oblique muscle presses the funiculus.
Is the shortening and reduction of the obliqueness of the inguinal canal not in contradiction with physiology? Obliqueness and the shortening of the inguinal canal do not seem to me to be of

any great physiological relevance. I believe that it is important that the deep and superficial rings ought not to be aligned, but staggered by 2-3 cm, so that the external oblique aponeurosis may effect the lower anatomic layers synergistically. What really counts is repairing the defense mechanisms.In my technique the rings are never aligned, even when the internal oblique muscle is inserted high on the rectus sheath, because in this case, the neo-deep ring is created in a position that is decidedly more cranial and medial compared to the original one.

McVay and Anson underlined the importance of repairing the anatomical planes and avoiding repair between different levels. Do you agree? My intention was to repair physiology not anatomy. Nevertheless, I can say that my repair is actually much more anatomical than it may appear to be.

Are the sutures between the two flaps of the external oblique aponeurosis not under traction? The external oblique aponeurosis is transversally very elastic. The sutures are executed in such a way as to avoid excessive traction and stress due to muscular contraction. The external oblique muscle contracts longitudinally and not transversally with respect to the suture line. Scarring is not impeded by the moderate tension of the suture, also because the aponeurosis receives a scarce blood flow and is, therefore, not subject to ischemia.

Is there not traction on the inguinal ligament with consequent risk of iatrogenic crural hernia? The risk of iatrogenic crural hernia is minimal even in techniques like Shouldice□s, which perform direct sutures along the whole inguinal ligament. Much has been written about this point.In my technique only the most superficial part of the inguinal ligament is barely involved and in no way subjected to transversal traction. I can also say that, since I began exploring the crural ring, I have never encountered crural pseudo-recurrences in my patients, while I have come across subclinical crural hernias in about 2% during primary hernia operations.

The technique seems to be complicated and rather difficult to learn and perform. Do you not agree? I also have the impression that this technique is not easily grasped and cannot really explain why. For some reason, some surgeons appear to learn it immediately, while others do not. It may depend on a surgeon□s ability to free him from traditional schemas. However, once the technique has been understood, it is not difficult to perform.As far " the feasibility" of the technique is concerned, two elements are important:

- the average operating time in my unit is about 30 minutes which indicates that the performance of the technique is not so complex
- neither recurrence nor significant complications occurred among the first patients operated availing of this technique. They represent a consistent group of patients who underwent the technique□s entire experimentation and improvement cycle. This fact corroborates the opinion that the clarity of each phase of the procedure reduces the risk of error to a minimum.

Is it not too much to use such a complicated technique in the case of simple hernias: should it not be for complicated cases only?Even the simplest hernias may recur. Hernias should never recur! I can understand a congenital hernia in a baby or in youths with a strong wall, cases which, in fact, I treat differently. But in most primary hernias, this physiological and versatile technique is quite appropriate.

In indirect hernias, the possibility of small associated direct hernias always exists. Might a technique which does not attempt systematic repair of the posterior wall of the canal not miss them?A systematic exploration of the fossa ovalis is always carried out to ensure that subclinical crural hernias do not exist. The same is true of the posterior wall of the canal where even tiny hernias of the transversalis fascia are easily detected.I have often located very small hernias on the rectus muscle near the pubis. They are located medially and might be missed even when the posterior wall of the canal is repaired. In my technique they are occluded by the external oblique aponeurosis. However they are easily recognizable. All one has to do is look.

Does this technique not produce more postoperative pain than techniques employing tension-free meshes?I am not in a position to compare mine with tension-free mesh techniques. What I can say is that compared to other traditional methods, this technique drastically reduces postoperative pain as is shown by the limited use of painkillers: required by 35% of the patients only. Even postoperative recovery is very rapid. After one week the majority of the patients are able to move without any problem.

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APPENDIX

12 THE "SANDWICH" TECHNIQUE IN INCISIONAL HERNIAS

This method was published by me in "Atti della Societa' Italiana di Chirurgia" in 1988, and later, in 1991, it appeared in the World Journal of Surgery as an original method by Matapurkar. This a technique particularly suited for the treatment of multiple incisional hernias and cases where the hernial defect is rigid due to fibrosis of the wall. Normally the mesh is a must but it means creating contact between the mesh, the bowel and subcutaneous tissue, with greater consequent risk of

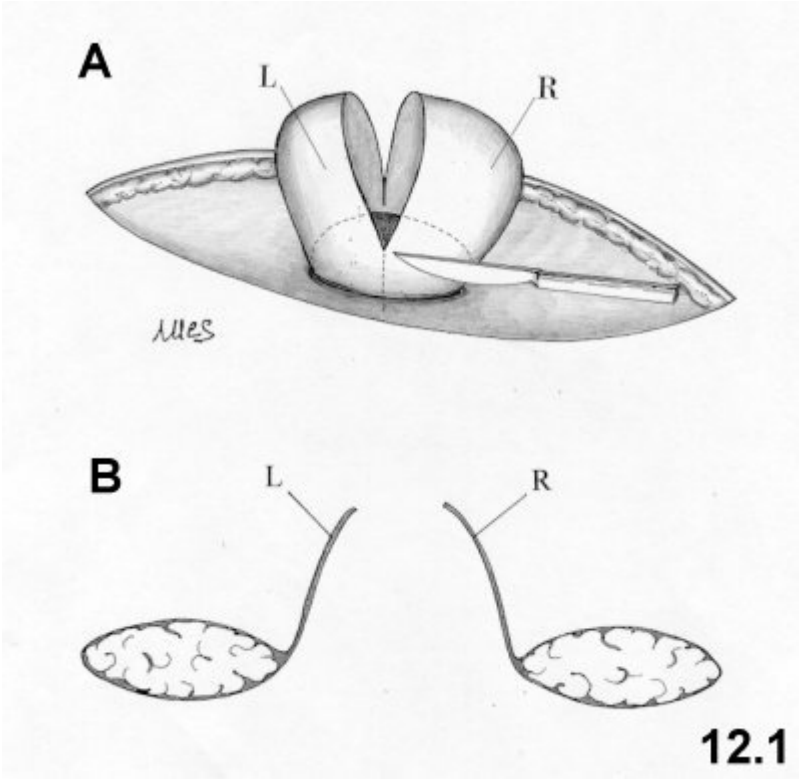
complication. The "Sandwich" technique permits that the mesh is separated from them, because the prosthesis is located between the two flaps created by the division of the hernial sac into two parts.

Incisions

Excision of the skin and subcutaneous tissue is generally preferred; this is performed by carrying out two incisions externally to the neck of the hernia sac, on scarfree tissue. In this way, the scar area which surrounds the sac is avoided and the fascial layer is easily reached. Following this level, the hernial defect and the sac ,which is neither resected nor opened until it has been isolated completely, are easily reached.

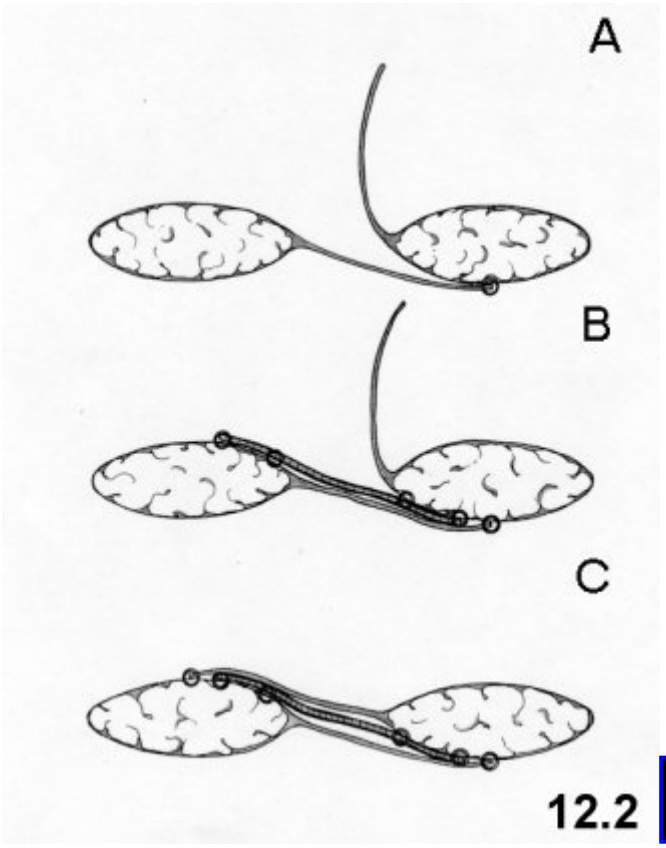
Treatment of the sac

In incisional hernias, the sac is a continuation of the aponeurotic muscular plane from which it may not be separated. As stated, the sac should not be resected; it is isolated as far as the neck and then divided longitudinally into two halves, perpendicular to the wall (Fig. 12.1). The adhesions are eliminated for a wide tract of the parietal peritoneum and the contents of the sac is pushed into the abdomen.



"Sandwich " Repair

The longitudinal division of the sac creates two flaps (Fig. 12.1A).The free edge of the flap on the surgeon□s side of the patient is positioned inside the hernial defect and is sutured to the parietal peritoneum along the entire free hemicircumference facing the insertion (Fig. 12.2A). The suture continues using synthetic absorbable thread, and is carried out at the greatest possible distance from the neck and includes, even if only partially, the muscular plane above it.A polypropylene mesh is shaped to the outline of the hernial defect, exceeding its diameter by 4 cm.. The hemicircumference on the side opposite the surgeon is fixed to the parietal peritoneum with a non-absorbable continuous suture concentric to the previous one.The other hemicircumference is sutured to the premuscular fascial layer (externally to the hernial defect).A third continuous suture is carried out with non-absorbable thread to anchor the mesh to the edge of the hernia defect (Fig. 12.2B).The second flap of the hernial sac (opposite the surgeon) is pulled over the mesh, so that to cover it completely (Fig. 12.2 C). The free hemicircumference is fixed on outside of the mesh at fascial layer, using the absorbable thread employed for the first suture.



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