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Inguinal hernia : the problem and the treatment

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INGUINAL HERNIA:

THE PROBLEM AND TREATMENT

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PREFACE

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J.A.R.

CHAPTER I

ANATOMY OF THE INGUINAL REGION

Probably no region in the human body so confuses the average medical student as the series of lectures dealing with the inguinal region. The musculature of the abdominal wall seems simple enough, each layer in its ordered place, each function exactly what one would expect of it. Yet, in that small area around the inguinal ligament all order is apparently cast to the wind and layers begin to overlap, split, and make contributions to the cord. Resulting from the great work of early anatomists, the student is suddenly faced with a whole host of eponyms. Moreover, some structures have a multiplicity of names. The eager student forges ahead; another struggles for the bare essentials; still another becomes confused and hopes another day will bring a less confusing area for him to dissect. The following comments hardly pretend to make the anatomy less complex. It is, however an attempt to the make the anatomy less confusing and secondly, to make the forthcoming comments on methods of hernial repair more sensible.

Since the abdominal wall is composed of layers, the following approach is taken: each of the layers will be discussed and references made to some of the

recent contributors to the body of anatomical knowledge cited.

The subjects which will be discussed are as follows:

1. The subcutaneous tissue
2. The external oblique muscle
3. The internal oblique muscle
4. The transversus abdominis muscle
5. The transversalis fascia
6. The rectus abdominis muscle
7. The pyramidalis muscle
8. The rectus sheath
9. The inguinal ligament
10. The abdominal fossai in the inguinal region
11. The internal inguinal ring
12. The inguinal canal

THE SUBCUTANEOUS TISSUE

The tela subcutanea, lying just beneath the skin of the front of the trunk is a fatty areolar tissue which has its greatest thickness on the front of the abdomen. Superiorly it is thin and weak, and is directly continuous with the fascia of the thorax. Inferiorly it becomes stronger and more dense. A thin, discontinuous, membranous layer is formed by the fusion of the connective tissue walls of the fat lobules within the fatty layer. In the lower part of the abdomen this layer assumes a more specialized character and comes to lie near the deep surface of the tela subcutanea. This layer is then called Scarpa's fascia. The fatty tissue superficial to it is called Camper's fascia. As the two layers of the superficial fascia descend from the inguinal to the femroal region they split, with Camper's fascia becoming directly continuous with the fatty superficial fascia of the thigh where it contains the subcutaneous inguinal lymph nodes. Anson and McVay,[211, 212] in their studies showed that Camper's fascia was traceable without pronounced local modification from the abdomen to the perineum and thigh and in the anal part of the perineum it is increased in bulk filling the ischiorectal fossa. Scarpa's fascia, being membranous in character, is carried downward without interruption in the region of the pubes,

over the spermatic cord, the penis and scrotum, into the perineum though it locally attached to the inguinal ligament. In the perineum it is continuous with Colles' fascia. Lateral to the spermatic cord, in the groin, Scarpa's fascia ends by blending with the fascia lata of the thigh. In the scrotum smooth muscle fibers replace the semi-membranous tissue to form the dartos muscle.

The abdominal wall is formed anteriorly and laterally by five pairs of muscles, and by the aponeuroses which serve as their tendons. Furthermore, the work of Anson and McVay[9, 10, 11] has shown that each of these muscle layers has an outer and inner investing layer of fascia. The significance of these layers is very important in hernial repair, since, as will be shown later, best results are obtained when fascia to fascia sutures are made. Of the muscles themselves, the two recti and the two pyramidalis are situated anteriorly. The recti are parallel to the midline and extend vertically from the pubic bone to the lower margin of the thorax. Laterally on each side, three muscul0-aponeurotic layers complete the wall,-the external oblique, the internal oblique, and the transversus abdominis. The muscle fibers of these three layers each takes a different direction. The external oblique corresponds with the direction of the

external intercostals coursing obliquely downward, forward, and medially. Conversely the internal oblique fibers, corresponding to the internal intercostals, run upward and medially. The fibers of the transversus abdominis, for the most part take a horizontal course.

The two obliques and the transversus extend to the midline in the form of an aponeurosis. The union of the aponeurosis from one side to the other results in the formation of the linea alba, which is a strong band extending midline from the pubic symphysis to the xyphoid process.

Thus, nature seems to have formed a formidable barrier against herniation. Closer examination, however, reveals certain weak points in this abdominal armor. The anatomy of the inguinal region, therefore, needs further explanation if the cause and the operative treatment are to have much meaning of purpose.

EXTERNAL OBLIQUE

As stated previously, each of the muscle layers has an outer and an inner investing layer of fascia. Though the tela subcutanea is regularly described as being two-layered, a third layer has been described--the innominate fascia of Gallaudet.[88] This fascial layer

is the outer investing fascia of the external oblique. It covers the external surface of the external oblique and its aponeurosis and, upon reaching the free edge of the inguinal ligament, extends inferiorly onto the thigh as the fascia lata. It also seems to have continuity with a homologous layer in the perineum, the inferior perineal fascia. On the inner surface of the muscle there is a thinner layer of fascia. The two fascial lamellae fuse at the free border of the inguinal ligament, continuing inferiorly, as stated, as the fascia lata. At the subcutaneous inguinal ring they likewise fuse to become the external spermatic fascia of the spermatic cord.

The external oblique muscle itself arises from eight digitate processes from the outer surfaces and lower borders of the lower eight ribs immediately lateral to where they join the cartilages. Of these digitations the first five slips interdigitate with the serratus anterior and the last three with the latissimus dorsi. Anson and Zimmerman are somewhat at variance with this, dividing the digitations four and four respectively. The general course of the fibers is downward and medial. However, the fibers originating from the fifth rib pass nearly horizontally forward, while those from ribs six and seven incline slightly downward and more medially to

about the level of the umbilicus, beyond the margin of the rectus. The fibers from the eighth and ninth ribs extend towards the anterior superior iliac spine but the muscle fibers themselves terminate along a curved line that runs from the anterior superior iliac spine towards the umbilicus. The muscle fibers from ribs ten, eleven, and twelve descend to the iliac crest.

The insertion of the external oblique is accomplished by a strong aponeurotic band that extends in front of the rectus to the linea alba where more superficial fibers interdigitate across the midline. This aponeurosis carries with it for the most part the outer and inner investing fascial layers. Superiorly the aponeurosis is attached to the xyphoid process and inferiorly to the inguinal ligament, though Anson and McVay argue the aponeurosis by no means fuses with the inguinal ligament and can be separated by dissection. Superiolaterally, the aponeurosis is attached to the anterior superior iliac spine and inferiomedially to the pubic tubercle and the pecten pubis. The aponeurosis is partially fused with the aponeurosis of the internal oblique lying in front of the rectus taking part in the formation of its sheath. The fusion takes place along a curved line that lies along the lateral border of the rectus above and reaches midline in front of the symphysis. Anson remarked

that the aponeurosis of the external oblique contributes very little to the lower portion of the rectus sheath. However, the composition of the rectus sheath will be discussed later in this chapter.

The diverging lower medial fibers of the aponeurosis of the external oblique just above the inguinal ligament and near its medial extremity form a cleft which is the external opening of the inguinal canal or the subcutaneous inguinal ring. The superior fibers form the upper boundry or superior crus of the ring and pass to the front of the symphysis. The inferior fibers form the inferior boundry or inferior crus of the ring and pass to the pubic tubercle. Between these two fiber band, intercrural or intercolumnar fibers arch about the lateral boundry of the ring and serve to strenghten the anterior and inferior walls of the inguinal canal. Some of the fibers of the superior crus intermingled with other fibers occasionally cross to the opposite side. This structure thus formed is called the reflected ligament or Colles' ligament or the triangular fascia. Actually, this ligament is of varible occurrence. Acording to Anson, it is present in less than one per cent of subjects bilaterally and less than three per cent of subjects unilaterally. At the triangular intercrural cleft only the inner and outer investing

fascia bridge the intercolumnar gap. In this gap the two layers are applied to each other back to back.

INTERNAL OBLIQUE

Like the other abdominal muscles the internal oblique has two fascial lamellae, which cover the inner and outer surfaces of the muscle and its aponeurosis, and in the areas where the muscle is deficient, fuse to form definite structures in their own right. In the lower parts of the internal oblique, beneath the cremasteric muscle the opposed outer and inner investing fascia fuse and continue downward behind the inguinal ligament. This layer is fused with a similar extension of the transversus layer to form the anterior wall of the femoral fascial tube. In the region of the inguinal canal the two fibers likewise fuse to form the internal spermatic fascia and since the cremasteric fibers are not applied to the cord directly, but from the anterolateral aspect, the fused fascial layers come to lie internal to the cremasteric fibers. The outer investing fascia of the cremasteric muscle, which will be shown later to be a part of the internal oblique, does continue external to the muscle and is called the cremasteric fascia, though the fascial character of the cremaster itself makes a fine division difficult.

Though the internal oblique itself is usually described as originating from the lateral half of the grooved abdominal surface of the inguinal ligament, it was the work of Anson and McVay that showed that the internal oblique does not originate from the inguinal ligament but that it rather has a loose fascial connection and that the fascicles actually arise from the iliopsoas fascia. The import of this finding is great in light of the numerous repairs that depend on the joining of some portion of the internal oblique and the inguinal ligament. Other points of origin are from the intermediate line of the anterior two-thirds of the iliac crest and from the vertebral column through the intermediation of the lumbodorsal fascia. From these origins the fibers radiate forward to form a sheet, their general direction being upward and medialward. The most dorsal fibers extend to the lower three ribs, where they become continuous with the internal intercostals. The lowest fibers from their origin around the inguinal ligament arch downward and medialward. Upon joining the lowest fibers of the transversus, they pass in fromt of the rectus muscle as part of its sheath to an insertion on the pubic crest and the iliopectineal line, behind the lacunar ligament and the reflected inguinal ligament. The part extending along the pectin is called the falx inguinalis

of the conjoined tendon. Blunt has stated that the internal oblique actually contributes very little to the formation of the conjoined tendon. This important structure will be further discussed later.

The fibers of the middle portion of the external oblique pass upward and medially, ending in a strong aponeurosis which extends from the inferior borders of the cartilages of the seventh and eighth ribs and the xyphoid process and into the linea alba throughout its length.

At the lateral margin of the rectus muscle the aponeurosis of the internal oblique splits into two lamellae, a superficial and a deep. The superficial layer passes in front of the rectus and fuses with the aponeurosis of the external oblique muscle. The deep layer is prolonged medially behind the rectus and becomes fused with the subsequent aponeurosis of the transversus muscle. However, at a point about medway between the umbilicus and the pubis the aponeurosis does not split, but as a single lamella passes entirely in front of the rectus to fuse with the overlying aponeurosis of the external oblique.

The cremaster muscle, a deriviative of the internal oblique, is well developed only in the male. It represents an extension of the lower border of the internal oblique

and possibly the transversus over the testis and the spermatic cord. It arises laterally chiefly from the medial part of the inguinal ligament and medially from the sheath of the rectus and the pubic tubercle. The lateral component is applied to the anterolateral aspect of the cord and the medial component is applied to the medioposterior portion of the cord though it is exceptional to find more than a fascial remnant of the medial component. When present, both components accompany the cord through the subcutaneous ring of the inguinal canal and become spread in loops over the testis. The cremaster muscle differs the other funnicular coats of the cord in that it does not completely surround the cord until just before this structure emerges through the subcutaneous ring. Ensheathing the cremaster muscle and between the scattered muscle fibers there is a thin membranous layer of connective tissue, the cremasteric or Cooper's fascia. As stated previously this fascial layer represents a continuation of the outer investing fascia of the internal oblique. Concerning the origin of the cremaster muscle it should be mentioned that Anson and McVay consider the origin of the muscle to be the iliopsoas fascia and its medial continuation, and the deeper of the two layers of the fascia lata over the femoral vessels. The cremaster's attachment to the inguinal ligament is accom-

plished only through the very delicate fasciae which cover the opposed surfaces of the muscle and ligament.

Blunt[31] in his detailed studies of the posterior wall of the inguinal canal found that the cremaster also adds some structural support to the wall of the canal. From the points of orgin the cremaster muscle divides into two heads which are superior and inferior. It is from the inferior head that the superior cremasteric fibers spring. The deep part of the canal includes the superior head and part of the inferior head; the cremaster fibers dip backward above and below the cord and gain attachments to the posterior wall of the canal. The attachment of the inferior head is almost entirely fascial wheras the superior head is attached by musculo-tendinous slips and by cremasteric fascia between the slips. Close to the deep inguinal ring the muscle slips are constant, but more medially the attachment is chiefly fascial. Where they meet the posterior wall these fascial fibers pass upwards and downwards to reinforce the posterior wall of the canal.

TRANSVERSUS ABDOMINIS

As in the case of the other abdominal muscle the transversus is also trilaminar in character. The outer investing fascia in contrast to those of the muscles

previously described does not have such a distinct character and usually is fused with the aponeurotic part of the transversus or the investing inner fascia. It is, however, the inner investing fascia that has a more specialized function. Its function has been so specialized that most anatomy texts refer to it as the transversalis fascia. Admittedly, there perhaps is still some debate as to whether the transversus, but the concept seems well established enough to place some credence on it.

As stated the transversus is trilaminar--one muscle layer with an outer and inner investing fascial layers. Since the outer investing fascial layer, by and large, accompanies the muscle aponeurosis it will be covered only briefly. Usually the muscle fibers do not extend as far inferiorly as the abdominal ring. Where the heavier tissue ends the two layers of investing fascia fuse to become a single stratum distal to the abdominal ring. The internal or transversalis will be discussed later in considerable more detail. Together the fused fascial layers adhere to the cord as the internal spermatic fascia.

The transversus is the deepest of the three muscle comprising the abdominal wall. It originates from the inner aspect of the cartilages of the lower

six ribs by indentations that interdigitate with the attachments of the diaphragm, from the internal lip of the iliac crest and lateral part of the inguinal ligament. Though this is the usual anatomical description, Chandler[51] found that the fibers originate only to a slight extent from the inguinal ligament and that they mainly are attached to the fused fascial layers, the transversalis fascia and the fascia iliaca, which lies at a deeper level. Chandler's findings were confirmed by Blunt as well as by Anson and McVay. Another site of origin is the aponeurosis of the lumbodorsal fascia.

The lumbodorsal fascia is essentially the posterior aponeurosis of the transversus muscle. As this fascia approaches the vertebral column, it splits into three layers or lamellae: the posterior lamella is attached to the tip of the spinous processes; the anterior lamella attaches to the tips and adjacent sides of the transverse processes.

Anteriorly the transversus muscle gives rise to a broad, thin belly and courses nearly transverse across the inner side of the abdominal wall. The lower fibers incline obliquely towards the pubis. The fleshy portion of the muscle terminates in a strong aponeurosis which is inserted in the linea alba, the pubic crest, and the iliopectineal line. The insertion of the transversus

abdomis into the ilio pectineal line is longer than that of the internal oblique.

In the upper two-thirds of the abdomen the aponeurosis extends behind the rectus to the linea alba and fuses with the inner lamina of the internal oblique. In the lower one-third of the abdomen it extends in front of the rectus to the linea alba and here also is fused with the aponeurosis of the internal oblique.

As the lower fibers attach successively to the front of the pubis along a line bordering the insertion of the rectus, the pubic tubercle, and the pectin pubis, the part lateral to the pubic tubercle, and the pectin pubis, the part lateral to the pubic tubercle is termed the falx inguinalis or the conjoined tendon. This is located behind the subcutaneous inguinal ring, strengthening this weak part of the abdominal wall. Since this structure is utilized in most hernial repair it will be examined more closely.

The conjoined tendon[52] is recognized as a union of the aponeurosis of the internal oblique and the transversus abdominis. This combined aponeurosis divides just lateral to the rectus muscle into two lamellai. The ventral one passes in front of the rectus as a part of its sheath and inserts into its fellow of the opposite side and inferiorly into the pubic crest and along the pectineal

line. The dorsal lamella attaches firmly to the lateral border of the rectus but sends a strong fibrous sheath to cover the whole dorsal surface of the muscle. This lamella attaches firmly below the lacunar ligament. Blunt has shown that the shorter aponeurotic fibers of the internal oblique frequently make little or no contribution to the formation of the conjoined tendon but run straight into the rectus sheath.

The inconsistency in the formation is a problem as is the presence or absence[128] of this Structure. Bloodgood[29] in his studies found that five per cent of men have a weak or obliterated conjoined tendon. He found that the hernias occurred after herniorrhaphy in fifty per cent of cases in which the conjoined tendon was of this type. The dependence of the Bassini repair on the conjoined tendon led many to question the vallidity of placing so great a emphasis on such an inconstant structure. Zieman,[320] for example, wrote an article in this same vein which he simply entitled "the fallacy of the conjoined tendon". Others came to question whether the conjoined tendon was a tendon at all. Anson and McVay found that in 97 per cent of cases there is a red muscle border, not a tendon-like structure, at the lateral margin of the internal oblique and transversus combined aponeurosis which is usually tendinous in its lower lateral portion,

is inserted into Cooper's ligament on the superior pubic ramus.

At the medial border of the abdominal ring and aponeurotic band, the interfoveolar ligament, extends between the lower arching border of the transversus and the inguinal ligament. This structure seems mainly to be a part of the transversalis fascia but may have a portion of the transversus aponeurosis in it also. It is composed of fibers that have crossed the midline from the transversus abdominis of the other side. Between the interfoveolar ligament and the falx inguinalis, the transversalis fascia forms the posterior wall of the inguinal canal. In this area a detached band of muscle fibers is sometimes found, the musculus interfoveolaris.

TRANSVERSALIS FASCIA

The transversalis fascia is a connective tissue or fascial membrane located between the peritoneum and the transversus abdominis muscle. It furnishes the chief fascial support for the anterior abdominal wall. In the inguinal region the transversalis fascia becomes thick and strong, reinforcing unprotected areas. Here the fibers assume a fan shape as they receive support at their different points of insertion. The handle

portion occupies the upward position and the lower or fan portion fastens onto the pubic bone and the different ligamentous tissues of this area. Along its medial portion it becomes blended with fascia of the rectus muscle and laterally to the dense iliopsoas fascia beneath the inguinal ligament. From the lower inguinal region it projects into the thigh with the femoral vessels as the femoral sheath. In the inguinal region the transversalis fascia is potentially weakened in two areas: the upper or mid portion of the fascia is pierced by the internal abdominal ring, and the lower portion, above the pubic bone, in the unprotected area commonly called the Hesselbach space, does not receive support from the internal oblique and the transversus abdominis muscles. As a result of its modifications in the inguinal region, the following component parts of the transversalis fascia are derived: the ligament of Hesselbach (ligament interfoveolare), Henle's ligament, the iliopubic tract and the sling-like attachments at the internal inguinal ring.

Ligament of Hesselbach or the Ligament Interfoveolare. The ligament of Hesselbach is located just lateral to the inferior epigastric vessels and along the medial margin of the internal inguinal ring in the inguinal space. Its fibers are chiefly vertical, and it

is triangular in shape, due to its attachment above and fixation below. Externally it receives fibers from the transversus abdominis aponeurosis. It is inserted below at the pecten of the pubis, where its fibers fuse into Cooper's ligament, and in its upper insertions its fibers pass laterally to the internal abdominal ring and medially across to the sheath of the rectus muscle. Its true ligamentous structure has been questioned by Anson and McVay who argued that the interfoveolare ligament or ligament of Hesselbach is not a true ligamentous structure, but merely a slight thickening in the transversalis fascia at the medial margin of the abdominal ring, which vanishes with the removal of the inferior epigastric vessels and their ensheathing preperitoneal connective tissue.

Ligament of Henle. Henle's ligament lies in the floor of the inguinal space. Its fibers run chiefly in the transverse direction. It is somewhat triangular in shape and concave above. Its base is inserted onto the pubic bone. Its outer fibers blend with the iliopectineal fascia, the base of Cooper's ligament, and the base of Hesselbach's ligament. Along its medial surface it receives fibers from the lower most portion of the rectus fascia.

The Iliopubic Tract or the Ligament of Thompson. The iliopubic tract forms the outer leaf of the transver-

salis fascia. It lies beneath the inguinal ligament. Medially it swings posteriorly and attaches to the pecten of the pubis, in company with the outer leaf of Henle's ligament, the base of Cooper's ligament, and the iliopectineal fascia. Laterally it is attached to the anterior superior iliac spine, where its fibers spread like a fan in a divergent manner, some going to the spine itself and others onto the internal lip of the iliac crest. It receives additional support from the femoral sheath and the iliopsoas fascia, which is partially evident as it crosses the femoral vessels. Roughly its fibers cross the inguinal space, blending with Hesselbach's ligament, and with the lateral border of the lineae albae.

Cooper's Ligament or the Superior Pubic Ligament. Cooper's ligament extends from the tubercle of the pubis along its superior border to the iliopectineal eminence. It is formed by the fusion of the pubic attachments of the three component portions of the transversalis fascia (Hesselbach's ligament, Henle's ligament, and the iliopubic tract), and the pectineal fascia. It appears as a thick, fibrous cord intimately adherent to the bone and runs posteriorly at an angle of 30 to 35 degrees to the inguinal ligament. Because of its strength and position its utilization in the repair of inguinal hernia is very

important.

The Inguinal Space. The inguinal space, or outer suprapubic space, is the space that is not covered by the transversus abdominis and internal oblique muscles. It is in this space that the transversalis fibers are the weakest and usually its fibers here run transversely. It represents the dome portion of the transversalis fascia, with the weakest support, commonly called Hesselbach's triangle, the base of which is formed by the medial side by the lateral border of the rectus abdominis muscle, and its lateral border by the inferior epigastric vessels. It is through this space that direct inguinal hernias occur. This space is divided into the middle inguinal fossa and the internal inguinal or supravesicular fossa, and it is through the middle inguinal fossa that the majority of direct inguinal hernias occur. Rarely does the hernia originate in the internal inguinal fossa, which lies medial to the obliterated umbilical artery; here the transversalis fascia gets support from the rectus muscle and the conjoined tendon. In dealing with a large direct inguinal hernia it is very important after the hernial sac has been dealt with to close the opening in the transversalis fascia through which closure is independent of the support obtained by approximating the different component portions of the transversalis fascia

and utilizing Cooper's ligament.

RECTUS ABDOMINIS MUSCLE

The rectus appears as a long, broad muscular band, which stretches from the pubis to the thorax on each side of the linea alba. It originates on each side by tendinous fibers from the pubic crest and the anterior pubic ligament. As the muscle ascends it becomes wider and thinner, finally inserting on the thorax as fleshy muscular fibers. The insertion takes place along the anterior surfaces of the fifth, sixth, and seventh costal cartilages and the xyphoid process. The medial border of the muscle is separated from that of its fellow by the linea alba. Below the umbilicus, where the linea alba is a fine line, the two recti are practically in contact with each other, but above the umvilicus they are about one-half inch apart.

The anterior surface of the muscle is crossed by three tendinous intersections: one at the costal margin, one at the umbilicus, and one between the two. A fourth may be present below the umbilicus, but is not constant. These zigzag, transverse, tendinous bands, the inscriptiones tendinae or linae transversai, are better developed on the ventral than on the dorsal surface of the muscle and intimately united to the ventral

wall of the sheath of the rectus. Since these intersections do not penetrate the entire muscle depth, the rectus is nowhere adherent posteriorly. By this arrangement a long muscle is divided into a number of shorter ones, thus increasing its strength and efficiency.

PYRAMIDALIS MUSCLE

Also included within the rectus sheath is the pyramidalis muscle. This triangular muscle lies in front of the rectus; it is frequently absent. It arises from the front of the pubis and is inserted into the lower part of the linea alba between the rectus and the anterior wall of its sheath. This muscle seems to have no role in the cause or cure of inguinal hernia.

THE RECTUS SHEATH

The sheath of the rectus in the upper part of its extent is formed externally by the aponeurosis of the external oblique; below the costal margin this aponeurosis passes in front of the external layer of the aponeruosis of the internal oblique and fuses with it. Walmsley[303] believes that the external oblique is not a true part of the rectus sheath but a superificial covering of it. He recognized the presence of an internal fascial invest-

ment distinct from the aponeurotic components of the sheath proper. In the lower portion of the abdomen the fusion of the aponeurosis takes place much nearer the linea alba than in the upper portion. At a variable distance below the umbilicus the aponeurosis of the transversus abdominis and the internal oblique inner aponeurotic layer, which above this level formed the posterior wall of the sheath, also pass to the front of the rectus. Hence, below this level the aponeurosis of all three flat muscles pass in front of the rectus and the posterior surface is left in contact with a fascial layer which is a medial extension of the transversalis fascia. Anson and McVay[213] point out that this membrane, which is designated transversalis fascia, is really a part of the fascial investment of the rectus and ought to be called the rectus fascia. The line that marks the lower limit of the dorsal ensheathment of the rectus by the aponeurosis of the transversus abdominis is called the linea semicircularis or the fold of Douglas. Its location varies from 0.25 to 4.25 inches below the umbilicus. Chouke[55] in his experiments found that two-thirds of the cadevers had the position of the fold about the level of the junction of the upper one-third with the middle third of the distance between the umbilicus and the symphysis pubis. Anson and McVay have observed that in most cases the fibers

of the internal oblique do not remain in the posterior wall of the sheath as far as the lines semicircularis. In 43 of their 56 cases the fibers froming the semicircularis were derived entirely from the tansversus abdominis. Furthermore, all the fibers of the posterior wall of the sheath may not pass in front of the rectus at the level of the semicircularis. In such cases those that remain behind may pass to the front either a few at a time or abruptly to form a second semicircularis at a lower level.

THE INGUINAL LIGAMENT

The inguinal ligament of Poupart's ligament is a strong band that extends along the lower margin of the aponeurosis of the external oblique from the anterior superior iliac spine to the pubis tubercle. Posteriorly the iliac fascia is fused to it. Distally the fascia lata of the thigh is attached to it. The internal oblique and transversus is said to originate in part from it but this point is in some debate due to the work of Anson and McVay. Medially near the attachment of the ligament to the pubic tubercle, fibers pass backward and medially to the pectin of the pubis and give rise to the triangular ligament or lacunar ligament or the ligament of Gimbernat. This is fused with the fascia of the pectineus muscle

and bounds the femoral ring medially.

More recent work has clarified the lacunar ligament. The ligament has been shown not to be composed of fibers sent dorsalward to form a triangular process of aponeurosis. Rather the inguinal and lacunar ligaments are parallel. The fibers of the lacunar ligament first fuse with the fascia of the pectineal fascia and using the latter as an intermediary, gain attachment to the pubic pectin. The margin of the lacunar then does not from the boundry of the femoral ring.

ABDOMINAL FOSSAE IN THE INGUINAL REGION

The hernias which occur so frequently in this region make knowledge of the inner surface of the abdominal wall of special importance. Medial to the abdominal inguinal ring, the inferior epigastric vessels give rise to a slight fold, the plica epigastric, that slants medialward and upward toward the rectus muscle. From the lateral margin of the insertion of the tendon of the rectus muscle upward towards the umbilicus there extends a better-marked fold, the plica umbilicalis lateralis, which contains the obliterated umbilical artery. Lateral to the plica epigastrica lies the fovea inguinalis lateralis, with the abdominal inguinal ring. Between the plica epigas-

trica and the plica umbilicalis lateralis lies the fovea inguinalis medialis. In the latter region the transversalis fascia which here forms the dorsal wall of the inguinal canal is strengthened by two longitudinal fibrous bands belonging to the aponeurosis of the transversus and transversalis fascia--the interfoveolar ligament at the medial side of the abdominal ring, and the conjoined tendon lateral to the rectus muscle. The bands vary in width. When they are narrow the part of the dorsal wall of the inguinal canal formed by the transversalis fascia and the peritoneum is relatively large, and extends far enough medially to lie, in part, behind the subcutaneous ring. Such a condition would favor the development of a direct inguinal hernia.

THE INTERNAL INGUINAL RING

Just what protective mechanism the internal inguinal ring provides at the place of exit of the spermatic cord has bewildered surgeons and anatomists for a long time. The ring seems to be a highly specialized anatomical part and for that reason is given special emphasis in this paper.

Sir Arthur Kieth[149] described a shutter mechanism, whereby the lower fibers of the internal oblique and transversus muscles become pressed against, and flush

with, Poupart's ligament, when the intra-abdominal pressure is raised in such acts as coughing and straining. In this way the internal ring and, especially, the posterior wall of the canal are protected against internal stress. Kieth regards the internal ring as a fixed opening.

Blunt[31] agreed with Kieth's findings noting that when the transversus contracts the deep margin of the ring moves laterally as a result of the attachment of its deep margin to the posterior aspect of the muscle and at the same time the whole of the posterior wall of the canal is tautened through tension on the same fascial attachments. Meanwhile the aponeurotic fibers of the transversus which turn downwards close to the deep inguinal ring are pulled laterally in the shutter action of the conjoined tendon described by Kieth.

Henry described the orifice as a vertical slit, a finding confirmed by Blunt, who found only by putting medial traction on the constituents of the spermatic cord as they emerge from the ring is it possible to convert the ring into a somewhat U-shaped orifice.

W.J. Lytle[184] regarded the ring as the pivot around which the transversalis fascia is arranged. It is not round but U-shaped and incomplete above, is placed obliquely and sometimes almost vertically. The opening in the adult measures from 12 to 20 mm. in height and from 6 to 10mm.

on breath. The ring is covered anteriorly by the transversus muscle, the fibers running obliquely downwards and inwards. The angle of the ring lies just below the edge of the transversus muscle to allow free passage of the cord. The ring is composed of strong U-shaped fibrous strands of varying length, the ends of which are attached firmly as slings to the posterior aspect of the transversus muscle. The ring has an appearance of a horn of plenty and the margins, which stand out, extend backwards at the angle as a tongue-shaped prolongation along the under surface of the cord. The shorter U-shaped strands form the body of the horn, while the longer strands lie on the rim. On each side of the ring the long strands spread out fanwise: on the outer side they pass up to be attached to the transversus muscle as far as the anterior iliac spine; on the inner side they gain attachment to the aponeurosis of the transversus muscle, while some pass medially to the back of the rectus muscle to join the band of Henle.

Lytle goes on to say that though the internal ring has been thought of as an inert opening, because of the attachment of the ends of its sling to the back of the obliquely arranged fibers of the transversus muscle, on the contraction of the muscle, should move upwards and outwards. Lytle's conclusion is, then, that when

a muscle is caused to contract, a stretch applied to it further enhances its contraction to a considerable degree. Thus it appears that a stretch reflex comes into action in protecting the inguinal canal. for any protrusion through the ring pulls on its slings and by stretching the transversus muscle calls the reflex into action. The action is that of a sliding valve. It cannot be described as a sphincter nor as a shutter, for it is designed to avoid undue pressure on the cord which both these mechanisms would tend to exert. The range of movement of the inner pillar is greater than that of the outer. The inner pillar is fixed to the inner part of the transversus muscle and to its aponeurosis where the maximum range of muscle movement occurs, while the outer pillar is attached to the muscle fibers near their origin where the muscle moves only slightly on contraction. There appears to be another protection of a more constant and passive nature provided at the opening. The margins of the ring stand out, and as the cord enters from the outer side and below, the inner margins or leaf overlaps the opening and thus acts as a lid or valve shielding it against more constant but varying intra-abdominal pressure.

Patey[228] induced the conjoined tendon, internal oblique, and transversus muscles to contract with faradic stimulation and found that the pillars of the

transversalis fascia sling constituting the medial margin are pulled laterally and upwards and that the arched fibers of the internal oblique constituting the lateral margin of the ring are moved medially. He concluded that the action is much like that described by Lytle and that in direct hernia the main protective mechanism is the transversalis fascia itself.

THE INGUINAL CANAL

Certainly this has been touched upon in the foregoing discussion, but perhaps a final description is still necessary. This area, by and large, is of the utmost importance to the surgeon. Too many faulty repairs and recurrences can still be attributed to a lack of anatomical knowledge of the surgical area.

The inguinal canal is a slit in the lower margin of the abdomen through which, in the male, the spermatic cord passes and, in the female, the ligamentum teres uteri. It is not a true canal. The inner end begins at the abdominal or internal ring which lies midway between the anterior superior iliac spine and the symphysis pubis, and from one third to half-way along a line which starts at the inguinal ligaments and passes to the lateral border of the rectus muscle.

From the abdominal inguinal ring, the spermatic

cord passes downward and forward in a space about 4 cm. long and then through the subcutaneous or external inguinal ring. The ventral or anterior wall of the inguinal canal is composed of the aponeurosis of the external oblique, the intercrural fibers, the cremaster muscle and in its lateral part, the internal oblique.

The caudal wall or floor of the space is formed medially chiefly by the lacunar or Gimbernat's ligament and laterally by the inguinal ligament and the iliopubic tract. Cranialward the wall in its lateral part is formed by the transversus and internal oblique muscles; in its medial part by the cremaster muscle. The dorsal or internal wall is formed laterally by the transversalis fascia; medially by the conjoint tendon or the falx inguinalis. The lateral part of the dorsal wall is thin but may be strengthened by a well-developed iliopubic tract. Near the abdominal inguinal ring, it is strengthened by the interfoveolar ligament and sometimes by the muscle slips of the interfoveolar muscle.

* * *

The anatomy is understandably a great problem, with each of the muscle layers in part protecting the cord and on the other hand contributing some component to the cord itself. This can not be explained on purely an anatomical basis alone. The descent of the testis

from its early embryological position must be taken into account. It is, then, the embryological and etiological factors which need to be considered next and will be discussed in the following pages.

CHAPTER II

ETIOLOGY OF INGUINAL HERNIA

If the fuller understanding of the anatomy of the inguinal region contributed greatly to the general concept of hernia, the fuller understanding of the etiological factors involved in hernia are similarly an important advance. From the preceding discussion of the anatomy of the region, it can be seen that there are certain anatomical factors that favor development of an inguinal hernia. These factors may be summarized as follows: the descent of the testis which carries with it a process of peritoneum, transversalis fascia, and cremaster muscle; weakness of the internal ring which makes it unable to resist sudden increase in intra-abdominal pressure caused by straining, coughing, whooping cough, pregnancy, obesity, ascites, and tumors; the fact that there is a weak point near the inner side of the internal ring that is unprotected by muscle and aponeurosis; the existence of an obliterated processus vaginalis or a preformed sac; anatomical variations in the length of the inguinal ligament has been considered by some writers to be a factor. Aside from the anatomical factors other factors have been considered in the etiology of hernia, such as lipomata of the cord, hereditary, age previous surgery, and trauma. Each of these factors will now be

discussed in some detail.

Descent of the Testis. In early fetal life the testis are located at the back part of the abdominal cavity, behind the peritoneum and below the kidneys, about on a level with the upper lumbar vertebrae. The anterior surface and sides are covered with peritoneum. By the second fetal month the testis and epididymis are attached to the genito-inguinal ligament. This ligament, which is at first a slender band, soon becomes well defined, and stretches from the testis to the lower part of the anterior abdominal wall where the scrotum is later formed. During the third fetal month the testis, guided by the ligament, descends to a position which corresponds to the internal abdominal ring.

With advancing growth, the peritoneum covering the testis envelops it entirely and forms a mesentery, and the muscular, fascial, and peritoneal layers of the anterior abdominal wall show a protrusion which results in the production of a sac--the inguinal bursa. This deepens and extends into the scrotal fold, which meanwhile is formed independently as an integumentary fol. The genito-inguinal ligament, being attached to the structures undergoing invagination, extends into the inguinal bursa. The muscular tissue of the wall of the bursa is derived from the internal oblique and transversalis, and constitutes

the cremaster. The lining of the inguinal bursa is the direct continuation of the general serous membrane of the abdominal cavity, and later it constitutes the processus vaginalis peritonei. By the fifth month the upper part of genito-inguinal ligament has disappeared and the lower portion has become a thick cord and produces an elevation of the floor of the bursa--the inguinal conus. During the seventh and eighth months the inguinal conus and attached testis are drawn downward into the inguinal canal and through it until shortly before birth the testis reaches its position in the scrotum.

The inguinal conus and the genito-inguinal ligament constitute the gubernaculum testis which becomes shorter and smaller as the testis descends. The remains of the gubernaculum testis constitute the scrotal ligament, the subserous band which permanently attaches the tunica vaginalis and testicle to the surrounding tissue of the walls of the scrotum.

The retroperitoneal position of the testis is always retained, the testis and the accompanying constituents of the spermatic cord descending outside the peritoneal pouch, which extends into the scrotum. For a time free intra-abdominal communication is maintained by the now tubular processus vaginalis. Usually, however, by the time of birth, or shortly after, this canal is

obliterated, the isolated, lower end of the peritoneal process persisting as the pouch of the tunica vaginalis shich almost surrounds the testis.

The processus vaginalis is the entire process of peritoneum that accompanies the testis and cord. It is divided into two portions: the funicular process, which invests the cord, and the tunica vaginalis testis, which surrounds the testis.

The processus vaginalis or funicular process, which appears at the third month of intrauterine life, is a canal or peritoneal diverticulum that entirely surrounds the testis and the epididymis, and is continuous with the peritoneal cavity.

The obliteration of the processus vaginalis occurs at two points, first at the internal abdominal ring, and a little later at a point just above the epididymis. Between these points, the processus vaginalis is an isolated tube which becomes smaller, its walls are occluded, and it finally terminates in a small fibrous cord, which is easily recognized during dissection or operation.

If the processus vaginalis does not become obliterated, a congenital hernia sac results, which may become a hernia, either at birth or in later life.

The obliteration of the processus vaginalis is

best studied during hernia operations of infants and children. When the processus vaginalis is obliterated only in its lower half or two thirds, it is easy to find a well-marked fibrous cord springing from the fundus of the sac at its lowest point. This cord can be traced down in the spermatic structures to the tunica vaginalis testis. Some times this obliterated portion of the processus vaginalis resembles the tail of a kite; often a well-defined mass of scar tissue is the dividing line between the open and the obliterated portion of the processus vaginalis.

Persistent Processus Vaginalis. Though the embryology seems clear enough now it has not always been so well understood. At the beginning of the twentieth century many writers debated as to whether a preformed sac actually existed or, if it did, whether it had any relationship to the development of a hernia, Thus, the so called saccular theory of hernia arose. Hamilton[112, 113, 114] published many articles on the saccular theory of the formation of hernia. His theory rejected the view that any hernia can ever be acquired in the pathological sense and maintained that the presence of a developmental peritoneal diverticulum or sac is a necessary antecedent condition in every case of hernia. Hamilton lists the following probable causes: variations

due to obliterative failure; primary anatomical variations due to developmental accidents; developmental accidents resulting in the implication of an abdominal organ in the formation of the processus vaginalis.

Murray[222] considered that if the congenital sac theory had any bearing at all, its applicability would be limited to infants, in which the sac is characteristically long, narrow, and distinctly constricted at its proximal end. In children and adults, however, he invariably found that the sac did not resemble the congenital tunica vaginalus but was always of a clearly differentiable acquired form and as constantly associated with atrophy of the muscles surrounding its abdominal opening. The sac in these instances, moreover, closely resembled that of a postoperative ventral hernia, in that it was a simple conical process of peritoneum evaginated through a relaxed abdominal, muscular os.

Murray[223] later endorsed the saccular theory, coming to recognize that during infancy and childhood two distinct varieties of the same type of congenital hernia sac are seen: the complete sac which involves the tunica vaginalis, and the incomplete sac which is entirely separate from the tunica vaginalis, the latter being much more common of the two. In the adult, also, two distinct varieties of the same type of hernia sac are

seen: the complete sac which involves the tunica vaginalis, and the incomplete, the latter being much the more common of the two.

Weakness of the Internal Ring. The embryological presence of a preformed sac is one factor, but other writers had other ideas of secondary factors involved. As a result of their studies a new understanding of the internal ring resulted.

Hammond[115] in 1923 explained the onset of hernia in a preformed sac as due to an incoordination of the muscles constituting the "sphincter of the internal ring". This occured in strain with some viscus descending into the sac during this momentary period of relaxation. In short, he regarded hernia as being dependent upon three factors; a persistent patent funicular process, an increase in intra-abdominal pressure, and a weak spot in the wall itself.

Mac Gregor[186] considered the most important factor in the etiology of inguinal hernia to be an insufficiency of sphincteric action on the part of the muscular ring at the internal opening of the inguinal canal, and that the other factors are only secondarily concerned in the final production of the peritoneal and visceral extrusion.

He noted that surrounding the spermatic cord at

the internal abdominal ring is a muscular structure for which the name "inguinal sphincter" is entirely justified. The sphincter is voluntary in character and, indeed, possesses a distinct motor supply. Functionally, it protects the internal ring, first, by a normal state of tonus, and, second, by voluntary contraction whenever the intra-abdominal tension is increased through abdominal muscular strain. When, however, the sphincter becomes, for any reason, relaxed or atrophic, the internal opening of the inguinal canal is left sufficiently patent to accommodate an entering wedge of peritoneum, extruded by the variations in intra-abdominal pressure. Sphincteric relaxation may be produced in a variety of ways, as, for instance:

1. Prolonged, exhaustive abdominal strain.
2. A sudden, severe increase in intra-abdominal tension.
3. Atrophy of the sphincter.

Lytle[184] whose anatomical work on the posterior of the inguinal canal has previously been alluded to, recognized the importance of the inguinal ring as a barrier to hernia. In cases of hernia which he observed he infariably found one of three abnormalities of the ring at the same time. These three abnormalities were: (1) weakness of ring; (2) ~~poor~~ mobility of ring; (3) a

dilated ring.

Though the importance of the internal ring is stressed, studies have been made on the importance of the subcutaneous or external inguinal ring. Chassin[53] studied 2,978 healthy young men and found 78.1 per cent of the subcutaneous rings were large enough to admit the examiner's index finger but concluded that enlargement of the subcutaneous ring should not be considered to be abnormal, nor that there is any conclusive evidence that it constitutes a predisposing factor in the pathenogenesis of inguinal hernia.

Gardiner[96] studied the results of 24,934 examinations made on government employees. From this rather large series 0.212 per cent developed hernia. In light of this, Gardiner restudied the physical examinations and found that of the 24,934 subjects 21,521 were noted to have normal rings. Only 0.176 per cent of these developed hernia. 3,413 subjects had previously been known to have had relaxed rings. 0.322 per cent of these subjects developed hernia. Gardiner, therefore, concluded that a civilian employee with a relaxed ring has a 2 to 1 chance of developing an industrial hernia, opposed to an employee with a normal ring.

Variations in Length of the Inguinal Ligament. F.J. Harris and A.S. White[122] found a definite relationship

between the length of the inguinal ligament and the occurence of either direct or indirect inguinal hernias. Individuals with an inguinal ligament less than 11 cm. have a slight tendency towards inguinal hernias. Hernia in individuals whose inguinal ligament measures 11-15 cm. are indirect inguinal hernias. Hernia occuring in individuals whose ligament measures 15-19 cm. are always direct. Recurrences are more frequent with long inguinal ligaments.

Lipomata of the Cord. There is often mention made of the fact that a lipoma of the cord is found many times during the hernial repair procedure. Speed[276] commented on the significance of these lipomas. He noted that when found, they should always be removed. If left behind, regardless of the operation used, or even if the cord is transplanted, they tend to cause a bulging of the inguinal canal and as a part of the preperitoneal fat, often being attached to it, they are subject to some downward strain in increased abdominal tension from any cause and exert traction on the peritoneal surface at or about the internal ring.

Hereditary. Though studies[219] have been conducted on this subject, there is to date no definite evidence that hernia is inherited. Certainly, one is often struck by the apparent propensity that some families

seem to have for exhibiting hernias, but this is apparently without a genetic basis.

Age as a Factor in Hernias. The age of a patient is a factor that actually has little to do with the type of hernia that a patient may have. Some hernias, present since birth, in the sense that a patent processus vaginalis persists, often do not make their appearance until older age. On the other hand, hernias are most likely to come down into preformed sacs following the activities of youth, the laborious occupations of adult life, and the strain of repeated pregnancies. Emaciation, due to disease or old age, may also be a factor by removing the fatty plugs that have kept the patent funnicular process temporarily closed.

Previous Abdominal Surgery as a Cause of Hernias. Early in 1911 Hoguet[131] called attention to the frequent occurence of right inguinal hernia following appendectomy with wound drainage. Hoguet attributed the occurrence of hernia to weakening of the abdominal wall following injury to the ilio-inguinal and iliohypogastric nerves.

Fisher[84] described a hernia characterized by a bulging at the external ring. The fascia at the site of the McBurney scar was intact, yet the abdominal contents had coursed through a defect in the peritoneum at the McBurney incision, found its way under the transversus

abdominis and internal oblique, presenting a mass at the external ring giving the impression of an inguinal hernia.

Thiessen,[295] although admitting that the cause of right-sided hernias following appendectomies may be due to increased abdominal pressure, omental adhesions to the peritoneum at the internal ring, or diminished resistance of the walls of the inguinal canal secondary to injury of the iliohypogastric and ilio-inguinal nerves, found in 31 cases that the defect was in the transversalis fascia. He argued that non-closure or non-healing of the fascia following a McBurney incision resulted in weakness, if not splitting apart, or the internal abdominal ring.

Hicks[129] noted a considerable number of right inguinal hernias following the McBurney incision for appendicitis. He recognized that in the transverse incision nerves could be better orientated and protected from injury.

Vineberg[301] also observed 3 cases of inguinal hernia following appendectomy. In all his cases, he found evidence of a scar of drainage at the McBurney incision. The hernial sac contained cecum and omentum in his cases.

One of the most definitive studies done on the

subject is that of Aune Pitkanen.[231] Pitkanen reported that after 1,062 appendectomies, 25 right inguinal hernias (2.4 per cent) occurred, 21 in mem and 4 in women. These findings suggested to him that the length of the incision and duration of drainage, as well as injury to the abdominal wall caused by the disease, were of great importance in the development of hernia. The fact that 23 of the hernias developed in cases in which drainage time was at least five days also pointed out the effect of drainage time.

Of 348 appendectomies in which McBurney's incision was used, 12(3.4 per cent) were followed by right inguinal hernia, whereas of 401 cases in which Lennander's incision was used only 10(2.5 per cent) were followed by hernias. After Krogius's incision hernia occurred in 3 of 313 cases(1 per cent).

Inguinal hernia after McBurney's incision was attributed to severing the ilio-inguinal and iliohypogastric nerves, and after Lennander's incision, to general functional disturbances of the abdominal layers. In both instances the general strain on the abdominal layers and the injury to them from the peritonitis were of importance. Krogius' incision did not seem to contribute to the development of inguinal hernia.

Relationship of Trauma to the Development of

Hernia. This subject has been one of great debate for many years, not only to surgeons but to compensation courts as well. Industrial medical literature has scores of references on this subject and there is no legal precedent on which new cases can be based. It would be nearly impossible for this paper to cite all the references on this aspect alone and secondly the value derived from it would not be worth the task it would entail.

Moorhead,[218] after analyzing 1,376 herniotomies come to the eonclusion that hernia can never be caused by trauma. The hernia may be aggravated if the source and symptoms are adequate. He felt that hernia is a chronic progressive disease and a large per cent of the population may have a hernia without ever knowing it. Moorhead concluded by saying that trauma is the cause of enough without saddling it with hernia and should be discarded like grape seeds as a cause of appendicitis.

* * *

Perhaps a few points should be made concerning the actual formation of inguinal hernia. There are two types, indirect and direct. The distinction between the two is on a number of points, i.e. whether the hernia enters the scrotum; the relationship of the hernial sac to the cord; the relationship of the hernia to the deep epigastric vessels. Various schemes have been devised to differentiate

the two types but unless the hernia had decended into the scrotal sac, the final diagnosis as to type can only be made at the time of operation.

Formation of Indirect Inguinal Hernia. It is generally believed that all indirect inguinal hernias are due to a preformed sac which consists of an unobliterated portion of the processus vaginalis. Given an exciting cause that increases intra-abdominal tension, the preformed sac together with a knuckle of small intestine or a piece of omentum is forced through the internal ring. The sac enters the inguinal canal above the cord and descends in front of it, lying lateral to the deep epigastric vessels. While a slight bulge over the internal ring may remain unchanged in size for years, once the sac has passed the ring it has overcome the point of greatest resistance, and progress down the inguinal canal is rapid. If the pillars of the external ring are well developed and the opening only large enough to allow the passage of the cord, the hernia may be temporarily checked in its descent at this point. Beyond the external ring, the coverings of the sac exert only very little resistance and the hernia quickly descends to a position opposite the upper level of the testis, where the firm connections between the coverings of the cord and the tunica vaginalis may check its progress. If it overcomes the

resistance here, it usually goes to the bottom of the scrotum and is known as a scrotal hernia. The obliquity of the inguinal canal is a natural obstacle to hernia, because an increase in intra-abdominal tension forces the inguinal walls more firmly together.

Formation of Direct Inguinal Hernia. Direct inguinal hernia is so named because it takes the most direct route through the abdominal wall, passing through only the lower fifth of the inguinal canal. The weak spot of the middle fossa is the usual point of exit of direct hernia. It is directly behind the lower fifth of the inguinal canal and the upper edge of the external ring between the outer edge of the rectus muscle and the deep epigastric artery, at a point where the abdominal wall contains no muscle layer, being weakened anteriorly by a gap in the external oblique aponeurosis at the external ring. The thinnest point, however, is at the upper and outer angle of the external ring where the posterior wall of the canal is not reenforced by the conjoined tendon or the triangular or Colles' ligament.

Direct hernias usually break through into the inguinal canal because the resistance is less in that direction that it is inward toward the rectus muscle. These hernias are never congenital and they have no preexisting path. They are of slow development and ordi-

narily occur in adults. They are characterized by a small sac with a relatively large opening, and because of the shortness of the neck of the sac, they are globular in shape.

With these principles in mind, the obvious question remains. How are these hernias to be repaired? This, after all, is the real nature of this investigation. As one might expect from the foregoing pages there has been considerable debate about the anatomy, the etiology of hernia. The surgical cure of hernia, too, has had to profit from trial and error, mistake and correction. It is no less dynamic than anatomy or embryology. To be sure, inflexibility can have its cons as well as its pros.

CHAPTER III

THE OPERATIVE TREATMENT OF HERNIA

Hernia, a disease known to man since his beginning, has a story which is parallel with the history of medicine. Archeologists, uncovering the ruins of ancient civilizations, have found statues of men with apparent hernias. Like so many other afflictions of mankind, hernia was an enigma through the centuries and attempts to solve its mystery by a multitude of methods were unfruitful. Credit for the first steps in solving the problems of hernia is given the anatomists. Andreas Vesalius of the sixteenth century, and later Fallopius, Gimbernat, Scarpa, Cooper, and others, made discoveries in the anatomy of the inguinal region which proved to be most valuable in the fundamental understanding of inguinal hernia. The next step in unraveling the riddle of hernia. The discoveries which gave birth to the science of bacteriology. It was from Pasteur's work that Lister revolutionized surgery by the institution of his first operation in 1869, using antisepsis. Oddly enough, Lister's first operation was a hernia case. Infection and suppuration, which had destroyed not only the surgeon's skillful work but frequently his patient as well, ceased to be the horrible result

that had previously plagued the surgeon. Lister's antiseptic methods reduced surgical mortality to one-twentieth of the former rate. The enthusiasm of surgeons was manifest by the introduction of a multitude of operations for hernia which were as numerous as the surgeons doing them. With so many different methods attempted in the surgical treatment of hernia, there were many recurrences of hernia, and it was obvious that there was a need for improvement in the technique. This came as another great step with the introduction of the Bassini and Halsted methods of hernia repair. The techniques were developed independently and reported at about the same time, 1890. Halsted later changed his original technique so that the essential difference from the Bassini method was in relation to the spermatic cord. Bassini reconstructed the tissue posterior to the cord, transplanting it anteriorly, whereas, Halsted reinforced the tissues anterior to the spermatic cord. Stronge as it may seem, these two methods have been the basis of operative repair of hernia to this day. All operations introduced have been modifications of these two original methods. New additions to the operative treatment of hernia have been made during the past fifty years and the operative

technique of surgery in general has been greatly refined by knowledge gained from researches in the basic sciences as well as the surgical skill manifested by the masters of the art. One of the outstanding contributors to hernia surgery since 1890 was Andrews, in 1895, who described a method of imbrication of the layers of the abdominal wall in which the transversalis, internal and external oblique muscles were sutured as one layer over the cord to Poupart's ligament and the lower flap of the external oblique was carried up over the upper flap and sutured to it. This was an advancing step in the treatment of direct hernia. Bloodgood in 1898 sutured a triangular flap of the rectus sheath to the inguinal ligament as a reinforcement of Hesselbach's triangle. In 1899, Ferguson closed the transversalis fascia tightly over the cord and made the internal obdominal ring smaller. McArthur, in 1901, suggested the use of the edge of the external oblique aponeurosis as a living fascia suture to unite the muscle to the inguinal ligament. In 1919, LaRoque devised an intra-abdominal removal of the hernial sac followed by the plastic repair of the inguinal structures. Hoguet, in 1920, advised opening the hernial sac near the internal inguinal ring in the repair of direct inguinal

hernia, a definite advance in the surgical technique in which the direct hernial sac is converted into an indirect sac by traction on the opened peritoneum at the internal abdominal ring and dissection of the preperitoneal structures from it. Gallie and Le Mesurier, in 1921, described the transplantation of fibrous tissues in the repair of anatomic defects by using fascia lata strips as suture material and graft. Pitzman, in the same year, stressed the importance of repair of defects in the transversalis fascia. Seelig and Chouke, in 1923, by experiments in dogs showed that muscle sutured to fascia resulted in poor union and suggested that fascial structures be sutured to fascia for the best results in the treatment of hernia. In 1934, Wangensteen presented a new application of an established principle in plastic surgery, the transplantation of the musculotendinous structure, the iliotibial tract, with its nerve and blood supply intact swung up from the thigh into defects of the abdominal wall. Anson and McVay, in 1938, by careful studies of the anatomy of the inguinal region, pointed out important relations of the muscle and fascia, and McVay, in 1939, on the basis of these new investigations discussed a fundamental error in the Bassini operation in that the inguinal ligament does not with-

stand very well the pull exerted by muscles sutured to it and suggested that better results could be obtained by the suture of the inferior aponeurosis of the transversus abdominis to the fibrous covering of the pubic pecten as far laterally as the femoral vein. Anson and McVay have contributed a great deal toward the improvements that may be made in the operative repair of inguinal hernia. Within recent years the use of metallic prosthesis has been used. Implants of skin, though known previously, came to be used more and more. Now each of these contributions will be examined in more detail.

THE BASSINI REPAIR

Dr. Eduard Bassini began his famous paper of 1889 as follows: [18, 19] "After all that has been written with such feverish diligence up to the present time concerning the radical cure of inguinal hernia it would certainly appear hazardous to publish something further on this subject. I resolved, therefore, to take up the treatment of this difficult and delicate theme only because I can illuminate the problem by demonstrative facts and diligent investigation on patients."

Bassini discussed the types of operations in vogue at that time, the high recurrence rate prevalent with these operations, the necessity of wearing a truss after operation, and briefly, his own experience with these operations. Of the operations prevalent at that time for the repair of inguinal hernia, Wood's and Czerny's were the most popular. Wood closed the enlarged inguinal canal, in which he invaginated a part of the hernia sac and closed the wall of the inguinal canal and the crus of the external opening over this invaginated part. Czerny, on the other hand, removed the hernia sac, let the neck retract and closed the external inguinal ring with deep sutures. Wood's method was only applicable with the reducible hernia, not with

the irreducible hernia.

Bassini conceived the idea that a radical cure might be obtained by a reconstruction of the inguinal canal, as it exists in the physiological condition, that is, a canal with two openings, one abdominal and one subcutaneous, and with two walls, one posterior and one anterior, through the middle of which the spermatic cord would pass obliquely. He found a method of operation which fulfilled the above mentioned requirements and made possible a radical cure without the necessity of wearing a truss.

The Bassini Operation: 1. Incise the skin in the inguinalscrotal region, exposing the aponeurosis of the external oblique muscle over the inguinal canal, exposing the cruri of the subcutaneous inguinal ring.

2. Cut through the aponeurosis of the external oblique muscle from the subcutaneous inguinal ring to the abdominal inguinal ring, free up the two leaves of the aponeurosis of the external oblique muscle, isolate and raise up the spermatic cord and the neck of the hernia sac. Then isolate the neck of the hernia sac up to the mouth of the hernia from the elements of the spermatic cord. The separation of the neck of the sac must be extended into the iliac fossa, above the mouth

of the sac itself. Next twist the neck of the sac, place a tie on the other side of the mouth and amputate the sac ½cm. from the ligature.

3. Retract the isolated spermatic cord, placing it on the abdominal wall. Retract the lower leaf of the aponeurosis of the external oblique muscle downward, the upper leaf upwards, exposing the groove which is formed by Poupart's ligament until the posterior edge and one cm. above the place where the spermatic cord comes out of the iliac fossa are exposed; next free up the external edge of the rectus abdominis muscle and the threefold layer which is formed by the Musculus oblique internus, M. transversus, the fascia transversalis, conjoined tendon, from the aponeurosis of the external oblique muscle and fromt the subserosal adipose tissue until the threefold layer can be sewed to the posterior edge of Poupart's ligament without difficulty. Sew these two parts together with interrupted sutures, for a length of 5 to 7 cm., from the crest of the os pubis to the point of emergence of the spermatic cord, which is shifted about 1 cm. towards the anterior superior iliac spine.

4. Place the spermatic cord in its place, suture together the aponeurosis of the external oblique until

the edges are sewed together down to the cruri of the spermatic cord, and unite the skin.

THE HALSTED I OPERATION

In 1893, at a staff meeting of the Johns Hopkins Hospital faculty, Wm. S. Halsted offered a new type of operation for the cure of inguinal hernia.[109, 110]

The operation was described as follows:

1. The incision begins at the external abdominal ring, and ends one inch or less to the inner side of the anterior superior spine of the ilium on an imaginary line connecting the anterior superior spines of the ilia.

The subcutaneous tissues are divided so as to expose clearly the aponeurosis of the external oblique muscle and the external abdominal ring. The aponeurosis of the external oblique muscle, the internal oblique and transversalis muscles and the transversalis fascia are cut through from the external abdominal ring to a point about 2 cm. above the external to the internal abdominal ring.

2. The vas deferens with its vessels is carefully isolated up to the outer termination of the incision, and held aside.

3. The sac is opened and dissected from the tissues which envelope it.

4. The abdominal cavity is closed by quilted sutures passed through the peritoneum at a level higher

by 1½-2 inches, than that of so-called neck of the sac.

5. The vas deferens and its vessels are transplanted to the upper outer angle of the wound.

6. 6 or 8 deep mattress sutures, pass through the aponeurosis of the external oblique muscle and through the internal oblique and transversalis muscles and the transversalis fascia, on the one side and Poupart's ligament and fibers of the aponeurosis of the external oblique muscle on the other.

The two outer most of these deep mattress sutures pass through muscular tissues and the same tissues on both sides of the wound.

7. The transplanted cord lies on the aponeurosis of the external oblique muscle and is covered by skin only.

THE HALSTED II OPERATION

In his paper of 1903, Halsted described his new operation for inguinal hernia.[111] A new feature of this operation of 1903 is the use of the cremaster muscle.

Halsted describes his new operation:

1. The aponeurosis of the external oblique muscle is divided and the two flaps reflected as in the Bassini-Halsted operation.

2. The cremaster muscle and fascia is split, not directly over the centre of the cord, but a little above it.

3. The internal oblique muscle is made as free as possible. If the muscle could not be drawn, without tension, well down to Poupart's ligament, he made a relaxation cut or two in the anterior sheath of the rectus muscle under the aponeurosis of the external oblique muscle.

4. Ligation of the sac by transfixtion or by purse string suture at the highest possible point. Both ends of this suture, after tying, are threaded on long curved needles, then carried far out under the internal oblique muscle from behind forwards, and, passing through this muscle, about 5 mm. apart,

are tied.

5. The lower flap of the cremaster muscle and its fascia is drawn up under the mobilized internal oblique muscle and held in this position by very fine silk stitches.

6. The internal oblique muscle, mobilized, and possible further released by incising the anterior sheath of the rectus muscle, is stitched (the conjoined tendon also) to Poupart's ligament in the Bassini-Halsted manner.

7. The aponeurosis of the external oblique muscle is overlapped as in Halsted I.

8. The skin is closed with a buried continuous silver suture, and the incision covered with five or six layers of silver foil.

THE ANDREWS IMBRICATION METHOD

E. W. Andrews [3, 4, 8] led the way in the newer attempts to strengthen the closure of the defect in the abdominal wall. He recommended suturing of the internal oblique and transversalis muscles to Poupart's ligament, according to the Bassini technique, and, in addition, advised that in the suture the mesial edge of the cut aponeurosis of the external oblique be included, and further that the outer flap of the external oblique aponeurosis should be imbricated over the suture line. He thus secured apposition of Poupart's ligament with the aponeurosis of the external oblique muscle and reinforced the union by the imbrication of the outer flap of the external oblique muscle.

The technique was described as follows:

1. The skin incision is made in the usual manner and the external ring exposed and cleared of its fibrous, fatty attachments. The ring must not be split upward haphazardly but the beginning of the incision of the external oblique aponeurosis must be placed a sufficient distance from Poupart's ligament in order to leave a sufficiently long lower flap to form an adequate covering for the cord. With this point in consideration, the canal was opened in the usual manner and the cord

elevated from its bed, opened, and removal of the sac accomplished. The incision in the cremasteric fascia may or may not be closed but the cord must be regathered into a compact mass adequately retracted, preferably upward, as this allows the placing of the stitches without moving the cord back and forth.

2. The insertion of the first portion of the stitch is the crucial part. It begins below Poupart's ligament and one must insert the finger into the femoral canal in order to avoid injuring the femoral vein which lies very close, beneath Poupart's ligament. After the point of the needle is brought into the canal, it is seized and carried through. The stitch then carries over to the conjoint tendon coming from within outward and taking a generous bite of its edge.

3. The needle is then reversed in the needle holder, and again coming from within outward so as to avoid injury to subjacent structures, a small bite is taken of the sharp, shelving edge of Poupart's ligament. The slack is then pulled up and the needle after being pulled through Poupart's ligament, is again reversed and goes back into the canal to take another generous bite of the upper fragment of the external oblique aponeurosis. Again reversing the needle, it is now

brought back toward Poupart's ligament and carried through the lower fragment of the external oblique aponeurosis very close to the ligament itself. Thus the stitch completely currounds Poupart's ligament. As the first loop is pulled, the conjoint tendon is drawn downward and underneath Poupart's ligament, and as the upper loop is pulled, the upper fragment of the external oblique aponeurosis is brought down and lies just above the sharp, knifelike edge of Poupart's. The result is then that when the stitches are pulled tightly, it is no longer a complicated double loop but is a single circle bringing the two structures snugly to Poupart's ligament with the ligament projecting in between them so as to give and edge-to-edge union.

4. The cord is then laid back in its bed just above Poupart's ligament and the upper fragment of the external oblique laid over it to make a roof for the canal. The subcutaneous tissues are brought together with a few interrupted plain catgut stitches and the skin closed.

Another repair procedure was to utilize the essentials of the Andrews' technique. Zimmerman's 321, 322 approach was to suture the outer, as opposed to the inner, flap of the external oblique behind the cord.

THE BLOODGOOD MODIFICATION

Bloodgood, as early as 1898[28] and in subsequent writings,[29] recognized that the Bassini operation left a weakness in the abdominal wall bounded laterally by Poupart's ligament and the rectus muscle, and below by the pubic bone. The firm and perfect closure of this opening is, therefore, hampered by the presence of the cord.

Bloodgood transplanted the rectus in order to suture it to Poupart's ligament and thus strengthen the defect in the lower angle of the wound due to the obliteration of the conjoined tendon. He also transplanted the cord and excised the veins as in the Halsted I operation.

After his initial publication in 1898, Bloodgood discontinued transplanting the cord and rarely excised the veins, though he continued the method of transplantation of the rectus, usually with Halsted's modification of transplanting its sheath.

Eastman[74] in 1924 reported a series in which the Bloodgood operation was employed with favorable results.

Perhaps the most important thing to result from Bloodgood's work was the fact that he recognized the necessity of the presence of the conjoined tendon for

the Bassini operation to be successful. As has been pointed out earlier, the conjoined tendon is a variable in both presence and structure. Thus the extreme dependence of the Bassini operation on the conjoined tendon will provide a stimulus to other investigators, as will be shown in the subsequent pages.

THE FERGUSON OPERATION

Alexander Hugh Ferguson[82] presented his collection of sixty-four cases representing his operation for the cure of inguinal hernia, in 1899, and published a book in 1907.

The operation is divided into four steps:

1. In his original paper he used only the strongly, upwardly curved incision, the "semilunar skin incision," but in his book the straight skin incision. He preferred the highly curved incision because of the greater exposure.

2. He exposes the contents of the inguinal canal by cutting through the aponeurosis of the external oblique muscle, far beyond the internal ring.

3. The hernia sac is opened, investigated and any excess omentum is suture-ligated and removed. The sac is ligated or sutured or, an internal purse string thrown around it. The veins of the cord should not be disturbed. The cremaster muscle is allowed to hug the cord and is reattached to the internal oblique muscle, for in this, its normal position, it is afforded an opportunity to resume its double function of holding down the muscle from which it originally received its muscular fibers, and by its contraction aid in emptying

out the valveless veins, in the cord. No part of the muscle should be removed, but its redudancy is taken up with the suturing of the transversalis fascia and internal oblique.

The transversalis fascia, which forms the internal inguinal ring, being stretched by the hernia, is sutured up with a separate suture or with the suture used to sew the internal oblique muscle to Poupart's ligament.

4. The internal oblique and transversus muscles are sutured to Poupart's ligament.

5. The sheath of the rectus if divided posteriorly and the belly of the muscle is brought out behind the internal oblique. The rectus abdominis muscle itself is sewed to Poupart's ligament. The aponeurosis of the external oblique muscle are sewed together in lateral folds or by overlapping. No. 1 chromic catgut is used to tie off the sac, Nos. 00 and 0 chromic catgut for all other sutures.

FREE FASCIAL TRANSPLANT METHODS

The earlier results of the operative procedures still left something to be desired. Other investigators began to inquire into the choice of suture material. The idea that fascia might make a good material began to be explored.

The first contribution of merit was by Lewis L. McArthur[198, 199] of Chicago in 1901. McArthur was the first to use fascia sutures, the strips of fascia being obtained from the split aponeurosis of the external oblique. He pointed out that the permanence of such a repair does not depend on foreign suture material and on apposition of scar tissue but on a lacing of the structures of the inguinal canal with living fascial sutures. A strip of fascia about 4 to 6 inches (10 to 15 cm.) long and about 1/8 to 1/4 inch (0.5 cm.) wide is obtained from the medial border of the external oblique fascia. This strip of fascia should not be separated from its attachment to the pubic tubercle. It is used to fasten the conjoined tendon to the inguinal ligament (Poupart's ligament) in order to obliterate the inguinal canal. In cases in which there is considerable relaxation of the tissues, a similar strip of fascia obtained from the lateral border

of the external oblique muscle may be used.

By means of animal investigation, McArthur demonstrated that living fascial sutures, that is, fascial sutures that are left attached to the pubic tubercle as previously described, will survive for months or years. This observation was confirmed by postmortem examination of human beings who had undergone herniorrhaphy in which living fascial sutures had been employed. Three years later McArthur reported no known recurrences in the eighty-five patients, eight of them having bilateral repairs. He noted that his method was equally adaptable to the Bassini, Halsted and other procedures.

In 1909 and 1913, Kirschner[150] demonstrated the feasibility of using free transplants of fascia lata for various operations. These transplants were used as substitutes for dura and tendons, for reinforcements of tendons, as substitutes for articular ligaments and other operations.

Kirschner found after many animal experiments in which various layers of the abdominal wall were sacrificed, that he could prevent the development of hernias with free fascial transplants. He recognized the resistant quality of transplanted fascia even under

the unfavorable circumstances of bad nutritional and septic conditions. Kirschner observed grafts for 101 days and found that they retained their characteristic structure and healed practically unchanged.

This was followed by more careful studied of fascial sutures by Lewis[176] and his associates in 1916 and 1917.

In 1921, W. E. Gallie and A. B. LeMesurier,[90] dissatisfied with their own and other surgeon's results in large, direct and recurrent hernias, went a step further than McArthur and Kirschner and used free transplants of strips of fascia lata. Their clinical work was predicated upon a series of carefully executed experiments. Studies were made of the effects of catgut, silk, and fascial sutures when inserted into the supporting structures of animals.

Gallie and LeMesurier[91, 92, 93, 94] demonstrated, with clinical and experimental evidence derived from rabbits and dogs, that long strips of fascia lata were ideal suture material for the repair of otherwise inoperable or recurrent hernias. They demonstrated experimentally that supporting structures sutured with autogenous free strips of fascia were much more strongly united than when sutured with catgut, linen or silk. Gallie and LeMesurier's results found considerable

conformation in the later researches of Gratz concerning the tensile strength and elasticity of[103] human fascia lata. This investigator found that, "The material showed surprisingly great tensile strength, comparing favorably with soft steel wire of the same weight; in addition, it showed an unexpected degree of elasticity." Gallie[95] reported a series of 200 cases in 1930, with only six failures, although among them were ventral and inguinal hernias so enormous as to be almost unbelievable. The strips which Gallie used were cut from the fascia lata through incisions in the lateral surface of the thigh. They were one-fourth inch wide, the length varying with the needs of the individual case, some of them being as long as 10 to 12 inches. Gallie sutured the defect in the thigh.

Seelig and Chouke[265, 266] contended that Gallie and LeMesurier failed in their dissections to identify properly the atrophic, frayed-out muscles--often all that remained following fixation. Muscle, deprived of function, rapidly atrophies; this change is hastened by the constant pressure to which it is subjected. This holds particularly true, they maintained, when the transversalis fascia is defective and there is a con-tration of intra-abdominal pressure prependicular to

its fibers. They undertook to investigate the moot question of the union of muscle and fascia. They concluded that normal muscle will not unite firmly with fascia and ligament. It is, therefore, a useless procedure to suture the abdominal muscles to the inguinal ligament in the hope of buttressing a weak or suptured an abdominal wall.

Koontz,[152, 153] on the other hand, demonstrated clearly that muscle united with fascia by the union of the fascia with the fibrous components of the muscle. The strength of this union depended upon intimacy of contact of the fascia with fibrous components of the muscle. It is necessary, therefore, that both muscle and fascia be stripped of areolar tissue before they are sutured together. This was later recommended by Rosenblat and Cooksey[253]. Still better results are obtained if raw surface of muscle is sutured to fascia.

In his paper, Edmund Andrews[6] showed clearly the fallacy of relying on red muscle in attempting to close the inguinal canal with nonliving sutures; he emphasized the important fact that Bassini himself recognized--the necessity of restoring the loss of continuity of the transversalis fascia, and he went far toward establishing the principle of utilizing only fibrous

connective tissue in re-enforcing the inguinal canal.

In seeking to obviate the necessity of a second operative site as in the Gallie procedure, Koontz made use of preserved fascia in hernial repair.[154] He found, in the case of dead tendon grafts that the preserved fascia became living by a process of repopulation by fibroblasts from the host.

In a study of comparative strengths, Horsley found fresh autogenous fascia lata to be superior to dead, preserved facial transplants.[133]

In 1934, after removing a large desmoid tumor from the left lower abdominal wall in a young woman, Wangensteen found the resulting defect so great that he was unable to close it by approximating the residual tissues.[304] The opening seemed to be too large to close with woven free strips of fascia lata so the plan of employing the iliotibal tract as a pedicled graft on the tensor fascia lata muscle suggested itself as a feasible procedure. The results were so satisfactory that he subsequently used the method with sucess in recurrent and large hernias of all types.

After exposing the defect in the abdominal wall, Wangensteen made a long elliptical incision in the thigh and raised a large flap of fascia lata with the pedicle

composed of muscle tensor fasciae latae. This muscle may be swung upward with its nerve and blood supply preserved intact. The innervation and blood supply of this muscle come from the superior gluteal nerve and artery and reach the muscle from behind where they course over the fibers of the gluteus minumus muscle. The transference of this musculotendinous graft may be easily made and its loss to the thigh does not compromise any function which it ordinarily performs. In the repair of large defects of the abdomial wall in which the loss of tissue precludes approximation, this pedicled graft is best drawn beneath Poupart's ligament with the superficial or fatty side down and sutured into the defect. In the repair of hernias, it is best brought up over Poupart's ligament and incoporated in the closure, the flap being slightly rotated at its base, so that the superficial or fatty side remains up.

This method was used in 1935 by Wadhams and Carabba[302] who took a pedicled flap of the tensor fascia lata over the inguinal ligament to form the posterior wall of the inguinal canal.

Burton and Ramos[46] made use of the femoral canal through which to conduct a similar pedicle.

Carl G. Burdick[41] and associates gave summary and end-results of fascial suture operations. Stimulated by

the favorable reports of Gallie and LeMesurier from 1924 to 1935, in 1,485 operations for hernia in 1,092 patients, fascia of some kind was used. The incidence of infection in the authors' series was lowest with autogenous fascia (7.9 per cent), much higher with homologous fascia (12.8 per cent) and ox fascia (12.1 percent). The number of recurrences was discouraging Fascia repair was reserved for only the more difficult types, but the authors had hoped for more encouraging results. In 975 followed operation for all types in which one of the three kinds of fascia was used, there were 284 (29.1 per cent) recurrences. Of these, 107 developed in less and 177 in more than one year, thus proving that a one year follow-up is inadequate for estimating the final percentage of recurrence.

Universal application of fascia in all hernias was urged by Moses Behrend[23, 24]. Use of homologous and heterogeneous fascia reduced recurrences. Fascia should be used in nearly every primary operation for hernia except in children. Fascia was obtained by means of a stripper. The main causes of recurrences were insufficient anatomic knowledge, infection and poor technic. Behrend had three recurrences in 125 cases operated on.

Swinton and Schwalm[293] of the Lahey Clinic advocated

the use of the fascial repair of hernias in all recurrent and direct hernias. They claimed that recurrences in the latter could be greatly reduced.

Culligan[65] stressed the value of the McArthur method of repair. In the great majority of cases of indirect hernia he stated that one strip is often sufficient. The rest of the repair can be completed with catgut.

Fleming[85] laid particular stress on the efficiency of the transversalis fascia.

R. Pilcher[230] used the plantaris tendon as a graft, and has fully described the technic.

In 1940 McCloskey and Lehman,[200] and also Joyce,[144] attempted to stimulate further interest in the use of fascia, and emphasized that it should not be reserved exclusively for very large and very difficult hernias, but should be used for all in which a repair other than the physiological type was indicated. Joyce advocated it for all primary direct and indirect inguinals, all femoral, and for all types of recurrent, also umbilical and ventral.

McCloskey and Lehman repaired large inguinal hernias by the McArthur technic. They used one strip, first passed through the conjoined tendon and then through the reflected portion of Poupart's ligament.

The suture is then passed back and forth through the internal oblique and transversalis fascia to the shelving edge of Poupart's ligament. Each loop of fascia was fixed with a linen or silk suture, and the external oblique aponeurosis sutured under the cord.

Smith and Masson[274] felt that all recurrent ventral hernias could be cured with fascia. They reported twelve ventral hernias operated on previously from one to five times.

Robins[250] advocated the use of the McArthur technic.

McLaughlin[206] reported 90 cases operated on by the McArthur technic. He also used this method in recurrences. There were no recurrences in this series, but too short a time had elapsed since operation to permit final conclusions.

Williamson[314] believed the Gallie operation gave appreciably better results than any other, especially in adults. Recurrences were placed at 1.3 per cent for indirect and 8.3 per cent for direct hernias. He, too stressed the inadequacy of the existing follow-up of cases.

Iason[137] believed that fascia lata transplant is justified on the following theoretic and practical grounds:

1. It is, above all, an attempt to produce better results.

2. Closure of large defects in the floor of the inguinal canal is not invariable successful.

3. Strips of fascia are nonabsorbable and do not rear through after insertion.

4. It is evident that living fascial sutures, unlike other sutures, do not drag the inguinal ligament and the tendon conjunctus together, distorting their relationships. The integrity of the inguinal ligament is preserved with their use. The darning serves as a re-enforcement in Hesselbach's triangle.

5. The iliotibial band is the only accessible and mobilizable fascial musculature available retaining its myodynamic integrity, that is, elasticity, contractility, and extensibility. The viability and therefore the tensile strength of a graft depends, first, on its connection with a base and the preservation of its nerve and vascular supply and second, on the width of the link. The nerve and vascular supply, highly situated, are not disturbed or destroyed.

6. The requisite amount of fascia is procurable from both thighs, if necessary.

7. There is no loss of bodily function in the transference of the graft.

8. The contiguous biceps femoris and vastus lateralis muscles do not herniate much, it at all, because they have their own fascial enveloping sheaths.

9. Surgical experience sustains the validity of the foregoing statements. The stansplantation of a live structure with intact nerve and blood supply is fully effective because the tonus of this musculofascial structure is preserved.

Iason's indications for the utilization of fascia lata transplants are:

1. Hernias difficult to repair by the customary surgical methods.

2. Large or massive inguinal hernias, complete or incomplete, direct or indirect, with a structural defect in Hesselbach's triangle, and musculature and aponeurosis which have lost their myodynamic integrity.

3. Recurrent hernias with large defects in Hesselbach's triangle.

4. Large or massive incisional hernias.

Iason operation: The usual inguinal incision is made and the external oblique aponeurosis is split parallel to the inguinal canal. The external oblique aponeurosis is then divided parallel to the inguinal canal to a point just beyond the abdominal inguinal ring, being careful to avoid injury to the subjacent ilio-inguinal nerve.

A vertical incision is then made along the anterolateral aspect of the thigh, its upper end curved somewhat anteriorly from a point above the anterior superior angle of the great trochanter, downward as far as required, revealing the iliotibial band. A sufficient section of this band is taken and of requisite width to reach, without tension, the entire hernial defect.

The pedicled fascial strip is then carried to the inguinal ligament subcutaneously. A slit is made in the inguinal ligament through which the fascial transplant is drawn. Three sutures are placed at this point in the ligament uniting the medial and lateral boundaries of the slit to the nearest portion of the fascial transplant is drawn. Three sutures are inserted, one at each angle of the gash and one in the center of the inguinal ligament. The free end of the transplant is then sutured to the tendo conjunctus and to the inferior aspect of the external oblique aponeurosis by No. 1 interrupted chromic catgut strands placed at intervals of about three-quarters of an inch. A single suture is then placed, approximating the middle section of the transplant above the inguinal ligament to the underlying transversalis fascia in order to eliminate dead space. The lower free border of the external oblique aponeurosis is finally

sutured to the upper free margin thereby placing the spermatic cord subcutaneously. The skin is closed with black silk sutures.

There were only four recurrences in his series of eighty cases with the use of fascia lata transplants. A bilateral fascia lata transplantation was done in one patient with a subsequent recurrence on one side, and in two, he failed to suture the medial part of the transplant to the lacunar ligament, thus permitting a bulge to occur in that area. In the fourth case, a postoperative incisional hernia, a defect recurred at the upper angle of the wound.

Guthrie, Olson, and Masson[107] analyzed the results in 2,298 patients and found a recurrence rate of 7.8 per cent with autongnous fascia as against 5.6 per cent for foreign suture material. They found that fascia was used much more frequently in severe and recurrent hernias, obese individuals, those with poor musculo-fascial development and in men. They felt that by giving reasonable weight to these disadvantages the small statistical difference could be more than discounted and favor placed with fascial suture.

As late as 1949, fascial repairs in the McArthur method were still being used. Mayo and Keeley[197] reported their results with this technic:

After making an incision in the usual position, the fascia of the external oblique muscle is divided in the direction of its fibers, and skin is retracted superolaterally to the upper limit of the tendinous portion of the external oblique muscle. A strip of fascia 10-15 cm. long and 1.5 cm. wide is obtained from the medial border of the external oblique fascia, but is not separated from its attachment to the pubic tubercle. After the hernial sac has been libated as high as possible, the free end of the fascial suture is threaded through a Gallie needle and used to fasten the conjoined tendon to the shelving edge of the inguinal ligament to obliterate the inguinal canal. Internal oblique fascia is approximated to the inguinal ligament by rolling the border of the muscle posteriorly. The external oblique fascia is closed beneath the spermatic cord with interrupted cotton sutures to make a new subcutaneous inguinal ring, and skin is closed over the structures of the spermatic cord.

Among 155 patients with unilateral inguinal hernias in whom this operation was done, the recurrences rate was 11.9 per cent in five years. Among 34 patients in whom bilateral hernias were repaired simultaneously, the recurrence rate was 13 per cent in five years.

End results of herniorrhaphy cannot be evaluated properly until five years after operation. Previous herniorrhaphy seldom distorts tissues sufficiently to make a subsequent McArthur type operation inadvisable.

Kidd[148] suggested another variant of the fascial graft technic. This author advocated an attached "postage stamp" living fascial graft for the repair of femoral hernia. A one inch square flap of external oblique aponeurosis is swung down and attached to Cooper's ligament. The femoral canal was thus closed by a trap-door of living fascia. This operation was used for the repair of fifty-three femoral hernias with two femoral recurrences.

THE LAROQUE INTRA-ABDOMINAL APPROACH TO HERNIA

LaRoque[169] in 1919 advocated the approach through a muscle-splitting incision above the internal ring for all inguinal hernias. He elaborated his technic in 1922[170] and described in detail the application of this method to sliding hernia in 1932[171]. Williams[312] in 1938 and Barnes[15] in 1939, who had adopted this method from LaRoque, later emphasized its advantages.

Moschowitz[221] in 1925 advised the use of a muscle-splitting incision for the reduction of small sliding hernias and a ventral incision for the large ones, but he closed the sac remaining in the inguinal canal from below.

Roscoe Graham[102] in 1935 reported the use of a rectus incision to reduce the hernia and to suture the mesocolon after dissection of the sac in the canal.

Carl Bearse[21] advocated intra-abdominal repair of femoral or inguinal hernia for patients who might be jeopardized by a supplementary hernioplasty at the time of a laparotomy. End results were given in 5 cases from 9 to 66 months.

Brown[37] in 1943 reported satisfaction in using a technic almost identical with that of LaRoque.

Jacobson[139] in 1946 advised the use of this technic

in all inguinal hernias.

Williams[313] said in 1947 that the advantages of this procedure are:

1. The dissection of the posterior portion of the bowel can be completed from above where a better view may be had of the blood vessels to the bowel; it is, therefore, easier and safer.

2. The entire sac and excess of peritoneum is removed, this is difficult from below and it is the most important part of any operation for indirect hernia.

3. Unusual conditions of the sac and its contents can be more readily recognized and repaired.

4. The muscle-splitting incision above the internal ring gives better access to the sac than the rectus incision, it is much more simple and easy, and it is adequate to handle the defect on either side of the body.

The essentials of the LaRoque technique are as follows: The usual hernia incision is made, perhaps slightly higher than usual, the aponeurosis of the external oblique is exposed and divided as in the ordinary operation. The muscle fibers of the internal oblique and the transversalis are separated, and the peritoneum

is opened just as if an appendectomy were going to be performed. Incarcerated and adherent structures are safely separated from the hernial sac. Dissection of the sac is greatly facilitated by enucleation from above, beginning in the natural line of cleavage between the peritoneum and its nonadherent coverings above the neck. The line of cleavage is easily found; enucleation downward in the natural direction beneath the fascia is done with little trauma to the cremaster, internal oblique and other muscles of the region. After removal of the sac, suture of the peritoneum is made at a point as high as desirable, sometimes 2 or 3 inches (5 or 7.6cm.) above the original location of the neck of the hernia, and if one chooses, by catching the transversalis fascia the peritoneal suture is fixed to a higher position. Whatever may be the most suitable for the individual case, may be employed in closing the canal and wound.

PITZMAN'S CONTRIBUTION TO HERNIAL REPAIR

Pitzman's[232, 233, 234] main contribution to hernia repair came as a result of his writings in which he stressed the importance of repairing defects in the transversalis fascia in surgical techniques. Bassini, according to Pitzman had erred in that his repair had cought the layer which had no physiologic anatomic basis and had missed the layer that was most important. Pitzman recognized that hernia was due not only to the weakness of the muscles and their aponeurosis but also the fascia as well. From an anatomic standpoint, Pitzman noted that that the subcutaneous ring and the greatest part of the abdominal ring were formed exclusively by aponeurosis and fascia.

The essential step of Pitzman's operation was to suture the transversalis fascia and the transversus aponeurosis, and only these layers, down to the inguinal ligament before the peritoneal cavity has been closed.

Pitzman's contribution seems a simple enough suggestion, yet the simple thing is often the most elusive. Prior to Pitzman's work, the repair of the transversalis fascia had been largely overlooked. Subsequent repair procedures were not to forget this apparent simple suggestion.

INJECTION TECHNIQUE

Though there are historical accounts of injection treatment for hernia, the enthusiasm that this method enjoyed started with the preliminary studies by Mayer[196] in 1927. Mayer reported that he had observed more than 2,100 hernias since 1899 with 98 per cent cure. The 2 per cent of his failures he cured by further injections. He saw no recurrence of his treated cases for a period of years.

Soon both European and American surgeons were employing this mode of treatment that seemed to offer the four objectives they had been seeking in hernia repair, that is, low mortality, few complications, no economic burdens to patient and no recurrence.

Fowler[86] thought that the claim of 98 per cent cure was reasonable. He had treated 700 cases in five years. He naturally assumed that, if patients do not return, their hernias were gone and forgotten. He treated all types of hernias, using a solution of plant extracts containing tannic and gallic acid irritants of meager description but having its own trade name advertised to the profession.

Rice[243, 244, 245] treated more than 600 cases at the Minneapolis General Hospital without complications.

He mentioned difficulties in follow-up but knew of only two failures.

Bratrud[34, 35, 36] of the University of Minnesota reported the treatment of 406 hernias in 387 patients. A very small number of these had been only fitted with trusses because of their advanced age or feebleness. The recurrences were a little less than 4 per cent including indirect and direct inguinal, femoral and epigastric hernias. In only three cases in which there was extreme difficulty in holding the hernia reduced was he had been unable to effect a complete closure.

Gray[104] of England followed Mayer's technique and claimed a 75 per cent cure. He gave no statistical analysis.

Crohn[63] felt that in a large number of patients who reject surgery, and who would otherwise go untreated except perhaps for a truss, will submit to the injection treatment. In proper hands, in carefully selected cases, the method is valuable; abuse is extremely easy and can cause general condemnation.

Wangensteen[305] felt that in selected cases the injection method had merit and when skillfully employed would appear to carry little risk of various complications.

Manoil[193] treated some 158 hernias in 123 patients. 92 per cent were between 41 and 90. Recurrence took

place in 26, and 5 were operated on after injection, making a total percentage of failures of 19.6. In the 15 patients between 11 and 40, there were no recurrences. There were no infections and no mortality. He believed the injection treatment was indicated in older patients considered poor risks and because of their state of nutrition or other co-existing conditions. It was also indicated in younger patients who refuse operation but are willing to cooperate in this treatment even though it is prolonged.

Arnold S. Jackson[138] reported only one complication in 3,250 injections in treating 420 hernias in 358 patients.

Biegeleisen and Tartakow[26] endorsed the method entirely. Their technique was centered on the internal ring in indirect hernia in the region of the transversalis fascia. In direct hernias, injections were aimed at the region of the conjoined tendon.

Edward Lamont Sugar[289] reported 150 cases closely followed for three years, with 1 per cent recurrences. He felt the procedure could be used on all cases regardless of age or size of hernia, except irreducible and sliding types and in hemophiliacs. In this series the only complication was local edema on initial injections

In spite of the glowing early reports, scientific knowledge demanded a better understanding of what was happening. A portent of the doom which was to come soon began as investigators started studying the histological effects of the injection substances.

Lazarus Mancil[192] investigated the histologic effects of various solutions for injection. The injection of certain sclerosing solutions into rats produced firm scar tissue in eight weeks. The presistence of foreign body giant cells two to eight weeks after injection of galtanor was noted, and it was suggested that its clinical use may be unfavorable. The systemic reaction following Bratrud's solution and of a modification of Mayer's solution as well as the marked necrosis of muscle following the injection of the latter made them unsatisfactory. The iodine and tannic acid solution, although producing marked fibrosis in the later stages, should be carefully investigated clinically because of the abssess formation noted in the 24 hour section. With Carabba's solution there were mild necrosis of muscle and a foreign body giant cell reaction in the seven day section only. This solution may be satisfactory for clinical use in proper doses. Sodium psylliate produces a mild inflammatory reaction,

slight necrosis of muscle in early stages, no systemic reaction intramuscularly and moderate reaction on intraperitoneal injection. It produces firm scar tissue without any undesirable changes.

Larson[173] of the University of Minnesota concluded that injections are suitable for umbilical, inguinal, femoral, and certain types of postoperative incisional herniae, making up in all at least 90 per cent of these cases which are seen. For the remaining 10 per cent of herniae, injections may be used to supplement surgical repair. He used the phenol, alcohol and thuja solution, averaging eight injections, and reported a 93.5 per cent cure in a total of 137 hernias, including direct and indirect hernias of all sizes occurring in all age groups. Practically the only complication, occurring in 10 per cent of the cases, was effusion into the hernial sac. The swelling subsided in three weeks but frequently necessitated aspiration. He concluded that no harm results from the injections should the method fail to cure.

Some surgeons reserved judgment such as Gallagher.[87] Others felt injection treatment to be a valuable adjunct to surgical treatment. Slobe,[273] for example, felt surgery was the treatment of choice but that injection

treatment was a valuable addition to the physicians means of treatment.

Judgment was being to be formed. Injection treatment was not the panacea after all. The treatment without recurrence became a medical joke.

Experience with the Injection Treatment was related by Claude L. Shields.[270] Injection was done 257 cases. Twenty per cent were absolute failures, all during the year when the largest number of patients was treated. The smallest number of injections to be effective was two. The largest number used to get a good result as 27.

Burdick and Coley[39] had a series of 66 cases with 92 herniae of various types which were treated by injections. Immediate results were gratifying and, generally, for a time no definite evidence of the existence of a hernia was present. However, in 47 of the 56 cases followed, a definite relapse was noted usually by both the patient and the doctor.

It was their, based on condition found at operation on several cases previously injected that it was extremely difficult to deliver the solution to the exact spot needed to obliterate the sac, and even when when the solution did cause a temporary proliferation

that either obliterated or masked the impulse, this tissue reaction gradually absorbed or diminished until a state was reached approximating that which had existed prior to the injection. Some scarring might persist, but that this strengthened the defense against a hernia was questionable except when it caused an obliteration of a narrow sac in an individual whose muscles and fascia were otherwise normal.

Harris and White[121, 123] had 236 patients treated by injection followed up for six months to three years after completion of treatment. There were 57 per cent cures, 28 per cent possible cures and 15 per cent complete failures.

George Earl[73] compared injection and surgical treatment. During 1933 and 1934, he operated on 38 patients and injected 42. He concluded that in selecting cases and advising patients concerning results with either operation or injection, ease of cure is in proportion to decade of life, size and character of hernia, general condition of health, patient's cooperation and doctor's interest, knowledge and experience in the procedure. A simple, indirect inguinal hernia was relatively easy of closure by chemical injection method All other types deserve careful study before treatment,

other than operation, is advised. In the aged or decrepit, injections may bring relief without cure. To secure results with the injection method takes more persistence, close attention to detail and study of the individual case than some are willing to give when operation offers satisfactory results. Because of recurrences and realizing that, after all, only scar tissue is secured from injections and this tends to give way, and because of the other difficulties discussed, he tends increasingly to advise operation more often that when first he began.

The worse was yet to come. If the injection treatment not only was ineffectual, it also began to be considered unsafe. The early enthusiasm rapidly waned in the face of reports of complications, sometimes fatal.[175] A few brief examples illuminate this point.

Ileus followed injection treatment in a patient seen by E. F. McDonough.[202] Injection treatment was shown to have, as one of its complications, intestinal obstruction due to adhesions around the bowel from entrance of sclerosing solution into abdomen.

Two fatalities after injection treatment were placed on record by Clarence J. Berne.[25] In the first case, the acute process progressed from the time of

injection, and in the second after an initial syndrome suggesting severe irritation of the bowel wall a quiescent period occurred, with sudden acute progressive episode five days later, probably indicating perforation. These cases constituted an indictment against the teaching that intraperitoneal injection is harmless and establish that laparotomy may be necessary at any time, as an emergency procedure.

The star had apparently begun to set for the injection treatment. The method had been shown to be ineffectual, often undully prolonged, and possibly fatal. The Americal Medical Association Council on Drugs decided to act. After due consideration, the Council re-affirmed its previous opinion that the injection method of treating hernia may not be recognized for general use and should be employed only by those with special experience and with full cognizance of the dangers involved in the use of such solutions.

This action was taken in 1940. The injection method is used little, if at all, now in the treatment of inguinal hernia.

THE COOPER'S LIGAMENT TECHNIQUE OR THE ANSON-MCVAY METHOD

From preceding remarks made on the anatomy of the inguinal region, considerable mention has been made of the work of Anson and McVay. Though the method of hernial repair utilizing Cooper's ligament is primarily a result of their studies and writings, the use of Cooper's ligament is in the literature prior to their work. Though the current interest in the use of Cooper's ligament began in 1939, the primary impetus came from the use of the ligament in the repair of femoral hernias. The McVay technique, then, had its origin in the work of Lotheissen.

In 1898 Lotheissen[181] cited the unpublished experiences of Narath with this procedure and Lotheissen reported the use of Cooper's ligament in the case of recurrent inguinal hernia himself. Lotheissen used the technique in twelve cases of femoral with no recurrences, the longest period of observation being one year. His method involved an exposure of Cooper's ligament by retracting the femoral vessels slightly laterally. He then sutured the muscular edge of the internal oblique to Cooper's ligament with four to five heavy silk sutures. The external oblique fascia

was then closed over the cord, after which the superficial tissues were brought together.

Fischer,[83] in 1919, stating that he had learned the operation from Kammerer, noted that he had treated thirty-seven instances of femoral hernia in this manner with no recurrences. In his technique he broke down Hesselbach's triangle to expose Cooper's ligament. The conjoined tendon was then sutured to the ligament of the external oblique closed over the cord in the manner of the Bassini operation.

Groves[106] in 1923 used a modified Lotheissen procedure in the treatment of twenty-one cases of femoral hernia during a ten year period. In his operation, Grove split Poupart's ligament and then had ready visibility so that the conjoined tendon could be sutured to Cooper's ligament from the pubic spine laterally to the femoral vessels.

Stetten in 1923[283, 284, 285, 286] also used the Lotheissen technique through an inguinal incision for femoral hernia. After drawing the femoral sac into the inguinal canal it was inverted and the typical suture of the edge of the conjoined tendon to Cooper's ligament covering the iliopectineal line was made as close to the femoral vein as could be safely done.

Andrews[5] in Chicago in 1924 used the Lotheissen technique to approximate the conjoined tendon and Cooper's ligament with kangaroo tendon in one case of large femoral hernia.

Keynes[146, 147] pointed out that in the treatment of femoral hernia suture of the Moschcowitz type would not last nor did he feel that an approximation of two tense structures such as the inguinal ligament of Cooper's ligament could be permanently maintained. Keynes differed from McVay in that he believed that the lower edge of the internal oblique, being muscular, not aponeurotic, could come down without much tension. In a six year period 125 cases were treated by suturing this muscular edge to Cooper's ligament, with only three known recurrences. In twenty-one additional cases, Keynes turned down a rather large semicircular flap from the internal oblique layer of the rectus sheath. This was turned at an angle of almost 270 degrees and sutured to Cooper's ligament from the pubic spine as far laterally as the femoral vessels.

Dickson[66] in 1936 stated that of all the operations previously proposed for the closure of the femoral hernia, the Lotheissen technique came to the nearest to fulfilling the requirements of the anatomical

and surgical principles involved. Dickson used a modification of the operation in which he sutured only the transversalis fascia rather than the entire conjoined tendon to Cooper's ligament. Dickson used this operation for femoral hernia only.

McClure and Fallis[201] (1939) also used the Lotheissen type of repair in about one-third of their series of ninety femoral hernias.

A most significant contribution came in 1942 from the fundalmental anatomic studies of Anson and McVay.[9, 10, 11] They emphasized the general misconceptions concerning the points of attachment of the inguinal layers.[214] Briefly their studies may be summarized as follows:

1. The inguinal ligament at its inferior and lateral aspects is a marginal structure. It is separate from the fascia of the thigh and is not attached to the internal oblique. It is held loosely in position by the surrounding fascia and my be shelled out of its fascial bed by a blunt instrument, to become the free margin of an aponeurosis which extends between the anterior iliac spine and the pubic tubercle.

2. The internal oblique arises not from the inguinal ligament as commonly stated, but rather from

the liopsoas fascia.

3. The inguinal portion of the transversus abdominis arises from the iliopsoas, and inserts not into the inguinal ligament but to Cooper's ligament on the superior pubic ramus.

4. Suture of the transversalis fascia, transversus abdominis, and internal oblique to the inguinal ligament violates the surgical principle of restoring musculofascial anatomy to normal. The inguinal ligament is not the insertion of any of these structures, and its relationship is simply one of contiguity.

McVay[210] advised, therefore, suturing of the inferior aponeuroses of the transversus obdominis and internal oblique to Cooper's ligament. McVay and Anson[215,216] used a single operative procedure in 100 consecutive operations for indirect inguinal, direct inguinal, and femoral hernias. In 56 of the 100 hernias classified as difficult to repair there were no recurrences. However, for those in the second group, it seemed to early at the time of writing to state definitely that there would be no recurrence.

Harkins, Szilagyi, Brush, and Williams[120] used the technique for 131 hernias in 109 patients during a sixteen month period. Their results indicated that the

procedure justified its theoretical advantages. At the time of their writing only one recurrence had been found.

Anderson,[2] in discussing the causes of failure in repair of inguinal hernia, felt that when the transversalis fascia is attached to Poupart's ligament instead of Cooper's an undesirable pocket is left. This is because the normal insertion of the fascia is Cooper's ligament and when it is sewn to Poupart's ligament a peritoneal through-like pouch tends to form the potential recurrent hernia. Anderson likened hernia to a tire and the transversalis fascia to the innertube. He then wondered if a tire is repaired by fastening the edge of the hole of the innertube to the outer casing. That seemed analogous to sewing the transversalis fascia to Poupart's ligament.

Harkins and Swenson[119] surveyed their experience with 322 hernias repaired by the McVay technique over a 38 month period. They had only one recurrence.

The suture of the transversalis fascia or of the conjoined tendon to Cooper's ligament is, according to Brunkow,[38] likened to pulling a curtain clear to the base of the window instead of only halfway for an effective blackout.

From observations regarding mechanical forces

applied to the inguinal region, Lich and Samson[177] concluded that a hernioplasty which employs Poupart's ligament creates trihedral upon the intra-abdominal pressure exerts a force against the hernioplasty wall about sixty-two times that exerted against the normal oblate ellipsoidal floor. They felt that the use of Cooper's, instead of Poupart's ligament was of great importance because then the normal ellipsoidal contour of the inguinal region was preserved. They also noted that the maximal pressure is only a few millimeters caudad to the deep epigastric vessels at the exact point of appearance of direct inguinal hernia.

In 1943 Satinsky and Mattson[195] applied the method as used by Harkins. To relieve tension they cut the rectus sheath as he did. Because of dissatisfaction with the relaxation thus produced and the inadequacy of the transversus abdominis in certain patients, they turned down a flap of rectus, a method which had been applied to the inguinal ligament. They believed the suture of a flap of the anterior and pyramidalis sheath to the superior pubic ligament (Cooper's) was a procedure indicated in direct inguinal hernias, indirect inguinal hernias with weak and redundant fascia in Hesselbach's triangle, recurrent inguinal hernias operated on previously by other methods, and femoral hernias.

Farris, Ettinger, and Weinberg[81] felt that uncomplicated indirect hernias were best dealt with by simple excision and transfixtion of the hernial sac with minimal disturbance to the cord or the floor of the canal. Complicated indirect, direct, recurrent, and femoral hernias were best repaired by the Cooper's ligament method, a modification of which they also presented. Their modification was that a flap in the internal portion of the rectus sheath was fashioned by incising the insertion of the rectus tendon and carrying the incision upward to about the level of the internal ring, and then outward to the lateral edge of the rectus sheath. The free edge if this flap was then rotated downward just as one would turn down the corner of a page in a book. This provided another freshly cut edge for accurate suture to the component previously fashioned from Cooper's ligament. The freshly cut edges are then united by interrupted sutures. The line of suture extended from the pubic tubercle below and medially, and to the femoral sheath above laterally. The femoral ring was therefore obliterated. The transversus aponeurotic layer, when available, could also be included in the line of suture. The lateral angle of the base of the rotated triangular flap was then carried

up and anchored to the inner border on the inguinal ligament.

Burton[44] felt the tardiness of the profession in accepting the use of Cooper's ligament in hernia repair could be attributed to the following reasons:

1. The decided lack of accurate and detailed knowledge or available textbook reference in this ligament.

2. The multiplicity of names by which this ligament is identified-- Cooper's pectineal, iliopectineal, pubic, and superior pubis ligament.

3. The false complacency of surgeons concerning, the results of the femoral, subinguinal, or inferior approach offered little incentive to developing other possible maneuvers in the hope of finding a better technique for the repair of femoral hernias.

4. Possibly the most important deterrent to the acceptance of the Cooper's ligament technique has been the potential technical difficulties encountered because the ligament is deeply placed, and the juxtaposition of the external iliac vessels creates the exagerated fear of inadvertently puncturing them.

5. Another important contributing factor which is retarding the acceptance of repair with Cooper's ligament

is the failure to establish definite criteria for its employment.

Burton then established what he hoped would be a definite criteria for the employment of this method.

1. Femoral loculation of the sac.
2. Insufficiency of the inguinal ligament.
3. Marked laxity of the parietal strata.
4. Arborization of the sac.
5. Multiple interfascicular defects with fascial incompetency.

Rice and Strickler described a method which employed the three generally accepted principles in the repair of hernia, namely, the use of locally available fascia for suture (McArthur) to approximate the inguinal strats to Cooper's ligament (McVay) and the reinforcement of the floor of the inguinal canal (Bassini).

Other writers on the subject of Cooper's ligament technique were Heritage,[125] Neuhof,[224] Hyde,[136] Swenson and Harkins,[291] Parsonnet,[226] Ross[254] McLaughlin and Brown,[207] Harkins and Schug,[118] Donald,[67] Holloway and Johnson,[132] Garner[97] and Lunn.[183]

One of the few criticisms of the Cooper's ligament technique is that of Zimmerman[323] (1948). This author made the following comments concerning the theoretical

advantages of the method. He stated that the objection to the use of Poupart's ligament that it fails because of lack of fixity of the structure to which the abdominal strats are sutured is invalid because if this were so recurrences would occur below Poupart's ligament in the femoral region. Zimmerman also pointed out that the Cooper's technique is more difficult technically. Zimmerman felt that the lateral portion of the inguinal canal cannot be closed in the Cooper's ligament technique because of the presence of femoral vessels crossing the superior pubic ramus.

The surgical steps of the Cooper's ligament technique will now be presented in some detail. Also included in the steps is the Hoguet Maneuver, based on the work of Hoguet to whom previous references have been made.

The repair procedure can be divided into ten steps. A step by step outline of the procedure follows:

1. Exposure of the Cord and Opening of the Indirect Sac--The incision in the skin is made from 1 cm. medial to the antero-superior iliac spine to cover the pubic spine, which exposes the external oblique aponeurosis. The external ring is exposed and the external oblique aponeurosis split in the direction of its fibers even with the upper border of the ring to allow for an

adequate lower flap. The split is then extended laterally and upward with scissors and then more carefully downward in the direction of the external ring after the iliohypogastric nerve has been carefully peeled away. The cord and the surrounding structures are then separated from the lower leaf of the external oblique aponeurosis and Poupart's ligament and then from the region of the pubic spine and conjoined tendon so that finally the cord is freed entirely except at both ends. The indirect sac is located upward and medially from the internal ring. In all cases, whether the hernia is direct inguinal or femoral, the indirect sac is opened.

2. Exploration of Hesselbach's Triangle and of the Femoral Ring,--once the indirect sac is opened, it is a simple matter to insert the finger and feel Hesselbach's triangle for a direct weakness or obvious direct hernia and to feel the femoral ring. Exploration with the finger tip of the femoral ring and Hesselbach's triangle should be an essential feature of all hernial repairs.

3. Hoguet's Maneuver--Transposition of Direct or Femoral Sacs Into the Indirect Sac.--If a direct sac is present, it should be transposed laterally to the inferior epigastric vessels by the technique of Hoguet (1920), which has since been popularized by Fallis.[130] [77, 78, 79]

Thus, the direct and indirect sacs are converted into one. This step is accomplished by traction outward on the indirect sac so that all of the peritoneum of the direct sac is pulled external to the vessels and the two sacs converted into one. An indirect sac can always be found in these cases, although it may be very small. The same procedure may be used to convert a femoral sac into an indirect sac, as practiced by McClure and Fallis.[201] This maneuver is extremely useful. In general, no matter how large a direct sac it is not opened but is merely transposed. In the case of large direct sacs the transversalis fascia can be infolded with numerous interrupted silk sutures. One advantage of not opening a direct sac is that the danger of opening the bladder is largely obviated. In some instances all three sacs can be converted into a single indirect sac, which in turn can always be dealt with as described in step 4.

4. Internal Purse-String Closure of Indirect Sac.--The indirect sac, whether it is simple or enlarged by the added conversion of direct and femoral sacs, is then closed with an internal purse-string suture of medium or heavy silk. Many stitches are taken with a round noncutting needle so as to include all crevices. Such a closure is done as high as possible to prevent indirect recurrences.

5. Plastic on the Internal Ring--MacGregor's Maneuver.--[187, 188] When the free ends of the purse string are cut and the peritoneum snaps back, the defect in the transversalis fascia at the internal ring is seen to be large and in many instances will admit even three or four fingers. The fascia is grasped with Allis clamps at numerous points around the internal ring above and medially as far as the inferior epigastric vessels--but not inferior to the cord--and a second partial or semilunar purse--string suture of medium or heavy silk ismade in the transversalis fascia. This ensures a snug fit around the cord, but the purse string itself does not surround the cord. Essentially, this step involves the suturing of the transversalis fascia, Henle's ligament and cremaster muscles together. Occasionally the conjoined tendon may be included in the sutures, but the shelving edge of Poupart's ligament should not be included since the normal and desirable retractile sphincter-like action of the internal ring demonstrated by MacGregor would be interfered with. The use of Henle's ligament has been especially described by Clark and Hashimoto.[56] They sutured as an initial step, Henle's ligament and adjacent portions of the aponeurosis of the transversus abdominis to Cooper's ligament along its

anterior one-third, an available surface of approximately two centimeters. This resulted in no undue tension, whereas, suturing these structures to the entire length of the ligament, namely, back to the area of the frmoral vein, did result in a definite tension and required a relaxing incision in the rectus sheath. The weak area of the transversalis fascia was further strengthened by attaching the transversus abdominis aponeurosis to the iliopubic tract as far as the internal abdominal inguinal ring. This produced a string pleat of transversalis fascia and raised and displaced the iliopubic tract closing the former defect. At the same time, this step produced a tight internal abdominal ring and closes the femoral canal.

6. Relaxation of the Internal Oblique Muscle.-- The inner layer of the anterior rectus fascia is usually split for a distance of about 3 inches (7.6 cm.) from a point 2 cm. above the pubic spine upward and laterally. This was described by Rienhoff.[242, 248] The external oblique was lifted up and the internal oblique cut just lateral to the junction of the two to where they form the linea alba. The rectus and pyramidalis muscles were exposed. The iliohypogastric nerve and the adjoining nerves and vessels which enter the rectus muscle

through the internal oblique aponeurosis at this point are avoided. This relaxation allowed the internal oblique and the attached transversalis fascia to be pulled down for the subsequent repair without tension.

7. Sutures Into Cooper's Ligament.--The "red" muscle of the internal oblique is entirely disregarded and even may be excised for convenience where it overlies the conjoined tendon. Usually it is elevated with a small retractor and the conjoined tendon l located. If the transversalis fascia appears strong enough, it alone is used for the upper leaf of the repair. If it is not adequate, one must go higher and include the internal oblique apneurosis. In no instance, however, should "red" muscle be used. The transversalis fascia, and often the conjoined tendon therefore, forms the upper leaf of the repair, while Cooper's ligament is an extremely tough thickening of the periosteal structure on the anterosuperior surface of the anterior ramus of the pubis.

During the first year or so that this repair was used, Cooper's ligament was visualized by breaking down Hesselbach's triange. Then for a year or so the sutures were applied blindly, Hesselbach's triangle being left intact. Recently, however, there has been

a return to the principle of direct visualization of Cooper's ligament. McVay used the method of direct visualization. After separation of the fascia over the anterior ramus, Cooper's ligament is exposed. The left index finger is placed on the anterior ramus of the pubis near the spine and moved laterally along the crest until the femoral vessels are reached. This is usually about 4 cm. lateral to the spine of the pubis. Since the finger is held in close contact with the bone, the vessels being kept lateral, and the first stitch is placed medial to the finger there is little danger of damaging the vessels. The first stitch is thus usually 3to 4 cm. lateral to the pubic spine. The stitch is then tied and the intervening gap between this point and the pubic spine is closed with three or four similar sutures. The most medial sutures usually go through Gimbernat's (lacunar) ligament as well as Cooper's. It is important that the most lateral suture be placed first, as otherwise it is more difficult to protect the vein. The sutures into Cooper's ligament are of silk. The double strands are made into a triple knot, individual strands are separated and tied in pairs. The space between the most lateral stitch in Cooper's ligament and the plastic suture on the internal ring often seems to

be a possible weak spot, but actually this is not so, because the arched internal oblique muscle will tend to close this defect on contraction.

8. Closure of the External Oblique Aponeurosis.--The external oblique aponeurosis may be closed beneath the cord after the manner of the Halsted-I procedure. The closure of the external oblique may be done in a typical Bassinie manner.

9. Closure of Scarpa's Fascia.--This closure is done with small bites of the suture.

10. Closure of the Skin.--Interrupted mattress sutures of silk are advisable for this step.

CUTIS GRAFTS AND WHOLE THICKNESS SKIN IMPLANTS

Rehn and Loewe were the first advocates of a method known to them as the cutis graft method for the repair of anatomical defects in hernia. Loewe[178] (1913) reportedthe use of cutis grafts in five cases of hernia and one of tendon repair. In describing the technic for removal of the graft, this author stated that the skin was removed with a scalpel in the manner of any full-thickness graft. The epidermis was then abraded away by scraping, as one would clean a carrot. The remaining tissue was then sutured over the defect under tension and the donor area was allowed to granulate and heal by second intention. Rehn[241] (1914) reported experiments on ten use of cutismaterial. Strips of twisted cutis were used as insert grafts in the Achilles tendon of dogs. Rehn stated that under the influence of continual tension, a gradual degeneration of epithelial elements occurred, and that the tissue assumed the appearance and functions of normal tendon in about ten weeks.

Loewe[179] in 1929 extended his observation on the clinical use of cutis grafts to almost 100 cases.

Uihlein[300] (1939) reviewedthe work of Rehn and presented 104 cases. Eighty of these operations were for

hernia.

Cannaday[47] (1942) was the first writer to report the use of cutis grafts in hernial repair in this country, presenting 14 such cases. In 1943, this author[48] made a later report, adding to his original cases and bringing the total to 37,27 of which were operations for hernia.

Swenson and Harkins[291] (1943) reported that in inguinal herniae skin gave just as good if not better results than fascia. The indication for cutis grafts seemed to be, therefore, as a reinforcement of an already carefully executed silk or other non-absorbable material repair. Later, Swenson and Harkins[292] (1943) reported two incisional herniae which were repaired with cutis graft reinforcement.

Henry N. Harkins[116] stated that bridging a fascial defect with fascia was seldom necessary in the repair of herniae and he had never seen a ventral or incisional hernia where the fascial layers could not be brought together. He advocated using cutis grafts only in incisional and ventral hernias.

Scola[262] (1944) reported the use of cutis grafts in the repair of two recurrent inguinal herniae and three incisional hernias. The cutis grafts were prepared by

Scola's special method: A full-thickness dermatome flap was cut and one end left attached. Fresh glue was applied to the dermatome. The underlying cutis was then disattached for use and the free peice of epidermis sutured over the donor defect.

Cannaday[48] (1944) reported a total series of 107 operations utilizing cutis grafts, 56 of which were operations for hernia. Cannaday expresses his position by stating: "Cutis may be used for any and every purpose for which fascia has been used, with the expectation of better results. . . After this clinical experience with the uses of cutis (derma) in repair surgery, I am convinced that it is one of the most useful autoplastic repair materials that we have, that it is superior in strength to fascia lata and of much easier availability; that success in its use can be expected in a large percentage of cases; that it is of special value in the surgical repair of large incisional herniae."

Whole-thickness Skin Implants.--This procedure is more radical than the introduction of cutis grafts. The method was introduced by Mair[189, 190] in 1938. Mair's technique was controlled by careful animal experiments. In two cases where the skin implant was examined later in human subjects, it was found to be

converted into stout fibrous tissue. Mair stated that he repaired 140 indirect inguinal herniae with the whole skin great technique and with a recurrence rate of 0.71 per cent after a follow-up of 1 year. He also repaired 40 direct inguinal herniae by the same technique without a recurrence at the end of 3 years. He found no contra-indication to the routine use of the operation where sound repair was indicated, but insisted on an adequate pre-operative skin preparation as being essential to elimination of sepsis as a complications.

As reported by Mair,[191] fascia had certain disadvantages:

The McArthur method did not give enough fascia to fulfill the requirements of the average case. The Gallie Technique involved either an extensive wound in the thigh or a small incision combined with the use of a fasciotome. In either case there was a risk of postoperative pain referred to the thigh and hip joint of the affected side and the possibility of obvious muscle hernia. Infection of the wound in the abdomen was more common after this method of herniorrhaphy then by others. Potential gaps existed between the strands of fascia and not always do all the strands unite with one another. The needle used for the Gallie

Method islarge and apt to traumatize the inguinal ligament. There was a substantial recurrence rate with fascial techniques.

West and Hicks[309] (1948) have also reported favorably on the use of whole skin grafts in the repair of inguinal hernia, particularly recurrent cases and femoral hernia. They used whole skin grafts in the repair of recurrent inguinal hernias and in inguinal hernias when a good rectus flap could not be obtained. The use of skin removed any objection to doing simultaneous double inguinal hernia operations, using the fascial graft on the one side and the skin graft on the other.

R. A. Richeson[247] stated that use of buried skin grafts in any type of hernia where fascia would ordinarily be used for re-enforcement minimized the complications and that the grafts do not have the disadvantages of fascia. In four cases in which Richeson used skin there were no postoperative complications and three patients have had no recurrence after 17 months; the fourth was operated on too recently for evaluation.

A. W. B. Strahan[287] reported results in 413 cases of inguinal, femoral, umbilical, and incisional hernias in which whole thickness skin was used as a repair material. No attempt was made to remove the epidermis,

and only suture of the graft under tension was relied on to secure the desired incorporation of the corium andcomplete removal of the embedded epithelial structures. Skin for the graft was usually taken from over the site of the hernia, but in some cases, if the skin was poor or the site of a scar from a previous operation, the incision was extended laterally to enclose an ellipse of skin with tougher corium.

Zavaleta and Uriburu, Jr.[319] presented a series composed of 87 primary inguinal hernias, 48 recurrent inguinal hernias, and 4 femoral, 21 umbilical and 51 incisional hernias. Mair's technique was followed, with modifications. Suppuration occurred in five patients; in one an inguinal hernia recurred; in two the graft was not tolerated, and in two there was a flase recurrence, the result of weakness of the walls in a zone distant from the graft.

Presently, the technique employed is as follows:

A 48 hour skin preparation is adequate. If the donor graft is obtained locally, the incision is elliptic and should provide enough tissue to repair the defect. The graft is then placedin isotonic saline solution. The most suitable type of hernia repair is carried out. In doing inguinal herniorrhaphy it is im-

portant to close the internal ring by carefully placed sutures in the transversalis fascia, both above and below. The conjoined tendon is then sutured to the shelving edge of Poupart's ligament with interrupted cotton sutures. If the cremaster fascia has been incised it is then closed with interrupted sutures.

The graft is prepared for placement by excising the ends and dissecting away all subcutaneous tissue. The broadest end is incised in its mid point for about 3/4 in. The graft is then laid in place with the incised end snugly surrounding the cord at the internal inguinal ring. Interrupted sutures are placed in the lower and lateral edge of the graft, which is sutured to the extreme shelving edge of Poupart's ligament, care being taken to suture the graft in situ under extreme tension. The inferior pole of the graft may be trimmedand sutured well down over the fascia of the symphysis pubis. The medial edge is sutured to the lateral aspect of the anterior sheath of the rectus muscle and the aponeurotic portion of the internal oblique muscle. Sutures are spaced 1/4 in. apart. The upper pole of the graft is sutured as near the reconstructed floor of the new inguinal canal as possible, in order to obliterate dead space. The rest of the

hernia repair is done according to Halsted's technic, which leaves no dead space around the cord as does the Bassini repair. Early ambulation may be used. The skin sutures are removed on the seventh or eighth postoperative day.

METALLIC PROSTHESES IN HERNIA REPAIR

The use of methallic prostheses an an adjunct to the repair of difficult hernias is not recent. Several metals were tried at the turn of the century, but quickly fell into disuse because they were either too rigid or bilolgically active with resultant sinus tract formation in the wounds. Phelps[229] in 1894 treated many inguinal hernias by placing coiled silver wire on the floor of the inguinal canal and approximating the layers of the abdominal wall over it. Witzel[317] in 1900, constructed, in the tissues, a rude network of crossed silver wires and suggested to the surgical world the idea of embedding a ready-made filigree. Goepel[98] also in 1900 was the first to make use of suce a ready-made filigree. Meyer[217] in 1902 reported the use of a silver wire netting made up after the fashion of ordinary mosquito bar. Bartlett[16] in 1903 introduced a filigree of wire loops, usually held in position by a central strand. These appliances were made of heavy silver wire. Many of them were so rigid that the discomfort of the patient dictated their subsequent removal. The sutures employed were also of silver wire, which frequently broke and became loose in the tissues. Wound infections occasionally developed, and,

with metallic implants in place, drainage was often prolonged. The use of silver filigrees in the manner of Bartlett was subsequently reported by McGavin[203] in England for hernias so large asto be considered inoperable.

It was not until 1948 when Koontz[155, 156] and Throckmorton[297] reported separately on the successful use of tantalum gauze mesh in hernia repair that interest was renewed. Since then other metals and plastic devices including stainless steel mesh have been tried, though Burke[42] had done some preliminary work on tantalum in 1940. Throckmorton used tantulum woven mesh gauze of monofilament tantalum wire, 2 to 5 mils. in diameter. Tantalum is a biologically inert foreign body and tissue repair progresses rapidly and unimpeded in its presence.

The essentials of the procedure are as follows:

The tantalum gauze herniorrhaphy performed for the cure of direct inguinal hernia associated with tiss tissue deficiency is as follows: The usual inguinal incision is made; the inguinal canal is opened by incising the fascia of the external oblique, and the structures of the cord are isolated. These are carefully examined for an indirect sac and retracted with a strip of Penrose rubber tubing. The direct weakness

is identified and the sac treated as the situation requires, either by excision or inversion. If the rent in the transversalis fascia can be repaired, this is done. No effort is made to suture a friable, attenuated, conjoined tendon to the inguinal ligament. Instead, the defect is covered with a patch of tantalum guaze. This is cut to size at the operating table, the edges doubled under, and it is sutured in place. All suture material in this repair, save purse strings and ligatures, is 10 mil tantalum wire. The tantalum implant is sutured medially to the periosteum of the pubic bone, the edge of the rectus sheath, and sturdy white fascia of the internal oblique muscle. Laterally, the sutures are usually placed in the shelving edge of the inguinal ligament. The structures of the cord are brought out through a small triangular opening made high on the lateral border of the implant. The cord is then placed in the subcutaneous position by closing the fascia of the external oblique beneath it and over the implant. The superficial fascia and skin are closed as usual.

Experimental observations comparing tantalum and stainless steel mesh in the dog were reported by Koontz and Kimberly.[165, 166, 167] The material and

the methods employed by them were almost identical to those of Spencer, Sawyer, Zeavin and Prevedel.[278]

Amos R. Koontz[157, 159, 161, 162, 163, 164] used tantalum mesh to repair abdominal wall defects. Most of them had large inguinal or ventral hernias and were obese. Included in his series was a child with a congenital defect, a patient with a defect due to a gunshot wound and several patients with recurrent inguinal hernias with large defects and poor tissues. Many of the defects could not be closed except by peritoneum, and tantalum mesh was used to replace the abdominal wall, either by suturing it to the fascial edges surrounding the defect or to the fascia a short distance from the edge of the defect. After repair of ventral hernias, stab wounds were placed in the most dependent portion of the dissected flap on each side, and a cigaret drain was introduced through the stab wound. Drains were removed in 24-72 hours.

The metal was well tolerated and produced no unfavorable reaction. It soon became coveredand infiltratedwith such dense fibrous tissue that the uotimate result was a firmer abdominal wall than that secured by other methods. Patients were followed from

1 week to 28 months, and results were excellent.

After Koontz's initial enthusiasm in 1948, other surgeons such as Jefferson and Dailey,[140] Lam, Szelagyi, and Puppendahl,[168] and Douglas[70] used tantalum gauze for repair of large incisonal hernia in which therewas a tissue deficiency with favorable results.

Preston[237] devised the following criterion for a material used for implantation in healing wounds. He felt that steel mesh was most useful but accepted tantalum as a worthy substitute. Preston's criteria were:

1. Biologically nonirritating in tissues; of inorganic composition.

2. Easily sterilized and not altered by sterilization.

3. Chemically inert in tissue fluids.

4. Pliable, nonrigid, to adjust with local movement in tissues.

5. Strong, to withstand local stress and intra-abdominal pressure.

6. Nonelectrolytic

7. Workable, not subject to fragmentation in the tissues.

8. Readily available and inexpensive.

9. Nonhydroscopic.

10. Nonopaque to roentgen rays.

McNealy and Glassman[209] used a solid vitallium plate in their inguinal hernial repairs. The plate was so contructed that the spermatic cord passed through an opening which offers protection to the region of the internal ring. The plate is also provided with perforations through which sutures can be inserted to hold it securely in place. Its position was such that it did not interfere with flexion of the thigh on the abdomen or with torsion of the pelvis. This plate was designed for those hernias that did not offer themselves to the usual methods of repair.

TECHNIQUE:

1. Inguinal incision.

2. External oblique aponeurosis was split in the direction of its fibers from the external ring to the level of the internal ring.

3. The cord is elevated.

4. The direct sac, medial and inferior to the deep epigastric artery is entered.

5. The deep epigastric vessels were doubly clamped, ligated, and cut.

6. The arched fibers of the transversus and internal oblique muscles were sewn down to the shelving portion of Poupart's ligament.

7. The vitallium plate was placed over the defect and the cord brought through the opening provided in the plate. The prosthesis lies in relation to the rectus sheath medially; the shelving edge of Poupart's ligament inferiorly; and the reched fibers of the inner two flat musclesof the abdomen superiorly.

8. The plate was anchored to the above named structures by interrupted wire sutures.

9. The external oblique aponeurosis which was split at the beginning of the operation was restored by suturing the two flaps together over the vitallium plate and cord. The plate was thus sutured around itsentire circumference; its posterior surface rests on the internal oblique muscle while the anterior surface lies immediately behind the aponeurosis of the external oblique.

SUMMARY

In the preceding pages the problem of hernia is approached in a systemic manner. The approach taken isto first more closely examine the anatomy of the inguinal region. One may think that the subject of anatomy has about reached the point of no return in terms of gross examination. Certainly the review of the literature shows that some of the most noteworthy advances have come in recent years. The section on anatomy in this paper takes each of the layers comprising the abdominal wall and discusses each of these in considerable detail. Moreover, some of the specialized structures of the inguinal region are also closer examined. The examination of these structures often entailed a review of numerous articles in the journals; often these journals presented conflicting views. Within the scope of the chapter an attempt was made to give equal recognition to each of these views, though the preponderance of material is gleened from the works of Anson and McVay.

If the knowledge of the anatomy of the inguinal region has been a progressive thing, in a similar vein the embryology and etiology of inguinal hernia has also been one of steady advance. In the second portion of

this paper the embryological events in the decent of the testis are discussed and note made of the resultant potential sites of hernia. In the same section the etiology of hernia is discussed, showing how the early confusion eventually became formulated into well defined concepts. Factors, though of not strict etiological cause but of import in terms of predisposition of hernia, are also discussed.

The operative treatment, the subject of section three of this paper, is in a sense a review historically of the procedures that have been used in the repair of inguinal hernia. Starting with Bassini's monumental work in 1889 and proceeding to the advances of the present day, the repair of inguinal hernia has been a steadily advancing field, both in terms of surgical techniques applied and in the awareness of the anatomy involved. Of the methods listed in section three, probably only one is not in great vogue today, that is, the injection technique. It, however, should be noted that some "medical" centers still advocate the use of this method.

Though not formally discussed in this paper, the bibliography at the conclusion lists articles which deal with other pertinent subjects allied with inguinal

hernia. For further information regarding the choice of treatment in infants and small children, the choice of treatment in older patients, the ideal suture material, the effects of early and late ambulation, and the type of anesthesia, the reader is referred to this listing. These subjects are, indeed, the germ of another discussion on yet another day.

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