The Use of Mersilene® Mesh in Repair of Abdominal Wall Hernias:

A Clinical and Experimental Study

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Use of synthetic materials in hernioplasty has been a controversial issue. In order to determine the influence of Mersilene® mesh on the strength of healing abdominal wounds and its effectiveness in repair of hernia, experimental and clinical studies were undertaken. Experimental study included 175 male rats divided into three groups subjected to either: 1) an incision made only through the skin and closed with 3-0 silk sutures; 2) a 2.5 cm midline incision through the musculature and peritoneum closed with 2-0 Mersilene® suture; or 3) the same procedure as group 2 with the addition of a Mersilene® mesh onlay graft. Bursting strength of abdominal wounds was determined in all groups at intervals. Wounds of the group treated with the mesh exhibited significantly greater ($P<0.01$) bursting strengths. Clinical trial consisted of 100 consecutive adult patients in which an onlay graft of Mersilene® mesh was used in the hernioplasty. Mesh was used as an adjunct in patients with: 1) large ventral hernias; 2) direct hernias resulting from severely attenuated transversalis fascia; 3) indirect hernias associated with a large internal ring and a weak posterior inguinal wall; or 4) combined direct and indirect hernias. All were followed for a minimum of one year to determine incidence of complication and rate of recurrence. This study suggests that: 1) Mersilene® mesh increases the strength of healing abdominal wounds in rats; and 2) repair of large hernias with Mersilene® mesh results in an acceptable morbidity and a lowered rate of recurrence.

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THE CONTROVERSY regarding the best method for repair of hernia is probably as old as the malady itself,[20] undoubtedly because the problem of herniation seems to be a simple mechanical one for which there should be a sure method of repair. Theoretic simplicity of a problem does not always result in a perfect solution. Thus, despite surgical advances, the foolproof herniorrhaphy still eludes us. Consequently, there has arisen a legion of suggestions to improve upon the repair of hernia. These proposals have suggested variations in the anatomic arrangement of the repair,[11] use of autogenous or homologous fascial tissue,[6] or placement of prosthetic materials to bolster the herniorrhaphy when the patient's own tissues seem to be inadequate.[3,17]

Use of prosthetic materials in repair of hernia has been accepted with variable enthusiasm throughout the years. Reports evaluating the use of such materials primarily concern the rate of infection and the host's tolerance after placement of synthetic materials. Some[8,16] have directed attention to recurrence of hernia following the use of prosthetic materials. As emphasized by Zimmerman,[19] in most instances of inguinal hernia, the actual rate of recurrence is far greater than that reported. Some factors which make it difficult to obtain accurate statistics are: 1) inadequate postoperative evaluation; 2) evaluation based on a questionnaire or another physician's examination; 3) variable criteria for recurrence; or 4) death of the patient. In our search of the literature, we found few reports[10,14,15] in which rate of recurrence was determined in every instance of examination by the operating surgeon. These data are summarized in Table 1. Also, there has been little documentation that prosthetic materials do indeed enhance wound strength.[2,4] The present experimental study and clinical trial was undertaken to determine if the use of mesh would: 1) contribute to the strength of healing of a wound; and 2) decrease the rate of recurrence in difficult hernias without increasing the incidence of complications.

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TABLE 1.

	Shuttleworth[15] & Davies	Marsden[10]	Nielsen[14] et al.
Year	1960	1962	1972
Cases	335	1602	343
Followup	4-12 yrs.	3 yrs.	2-12 yrs.
Total recurrences	14.3%	6.8%	14.5%
Indirect	14.2%	5.2%	
Direct	18.3%	7.4%	14.5%
Recurrent		19.0%	

Experimental Study

Methods. Male Sprague-Dawley rats were used. These animals weighed 150 to 200 grams at the beginning of the study. The animals were housed in an air-conditioned room maintained at a uniform temperature of 75F, and were fed a standard pellet diet with water *ad lib.* After the introduction of anesthesia with sodium pentobarbital, the rat's abdomen was clipped of hair and painted with iodine. Animals were then assigned to three groups.

Group 1 comprised 35 rats which were subjected to a sham operation in which only an incision in the skin was made and then closed with 3-0 silk.

Group 2 consisted of 70 animals in which a 2.5 cm midline abdominal incision was made through the musculature and peritoneum. This incision was then closed with 2-0 Mersilene®* interrupted sutures placed exactly 5 mm apart and 5 mm from the edge of the wound. The skin was closed with a continuous suture of 3-0 silk.

Group 3 consisted of 70 animals which were treated as group 2. In addition, prior to closing the skin, a 2.0 cm x 3.5 cm rectangle of Mersilene®** mesh was applied as an onlay graft over the abdominal incision. This graft was secured with a continuous suture of 2-0 Mersilene® (Fig. 1). All animals were returned to their cages to recover.

Bursting strengths of the intact abdominal walls of group one and of the abdominal wounds of groups 2 and 3 were then determined 3 and 5 days, and 1, 2, 4, 8 and 16 weeks postoperatively. The procedure used for determining bursting strength was a modification of that described by Myers[12] in which the abdominal wall is placed in a pneumatic tensiometer. The wound is then exposed to a steadily increasing amount of air pressure until dehiscence occurs. When disruption of the wound occurs, an immediate drop in pressure is recorded on a Sanborn pressure recorder, Model 127. Bursting pressure of the wound was the maximum pressure in pounds per square inch (PSI) needed to disrupt the wound or normal abdominal wall. This method for testing wound strength was selected because exposure of the wounds to an increasing internal pressure is a fairly close approximation to the elevations of intra-abdominal pressure which weaken repair of a hernia. Furthermore, since this study was an attempt to simulate the conditions under which a herniorrhaphy might break down, all sutures except those in the skin were left in place when the bursting strength was determined. Animals which showed evidence of infection were discarded. The mean of the bursting pressures at each test period was calculated and the significance of difference between groups was determined by the Student *t* test.

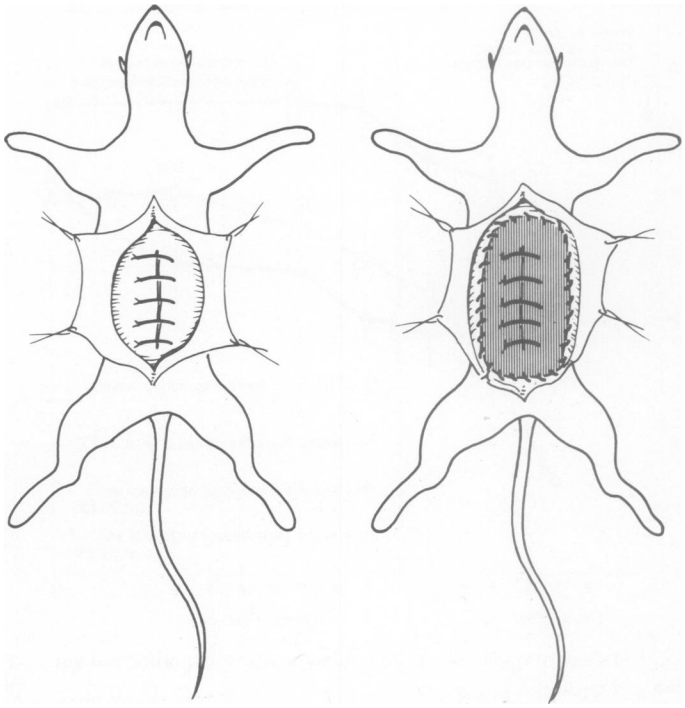

FIG. 1. Technique used to close the musculoperitoneal defects in two groups of experimental animals. On the left the defect is closed without a graft; on the right, an onlay graft of Mersilene® mesh is added.

Results

The results of studies in which the bursting strengths of wounds in the abdominal wall of rats were determined are summarized in Fig. 2. In sham-operated animals bursting strength of unwounded abdominal walls increased steadily throughout the time periods studied. During the 16 weeks of testing time, the rats in our study doubled in weight. This increase in weight paralleled the increase in bursting strength. By the end of the testing period, the bursting strength of the abdominal wall of sham-operated animals was twice that seen at the third postoperative day: 32.4 PSI vs. 16.4 PSI, respectively. These findings are consistent with the results of Levenson and co-workers[9] who reported that the breaking strength of unwounded skin of animals of different ages is directly related to the weight of the animals.

Until the seventh postoperative day, abdominal wounds which were closed with Mersilene® sutures alone

*Ethicon, Inc., Somerville, New Jersey.
**Polyester fiber mesh, Ethicon, Inc., Somerville, New Jersey.

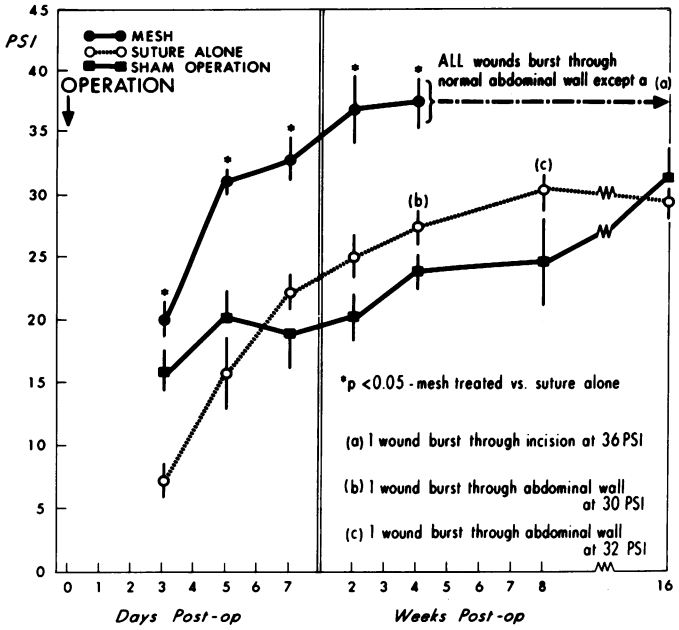

FIG. 2. Bursting strengths of rat abdominal walls in experimental animals.

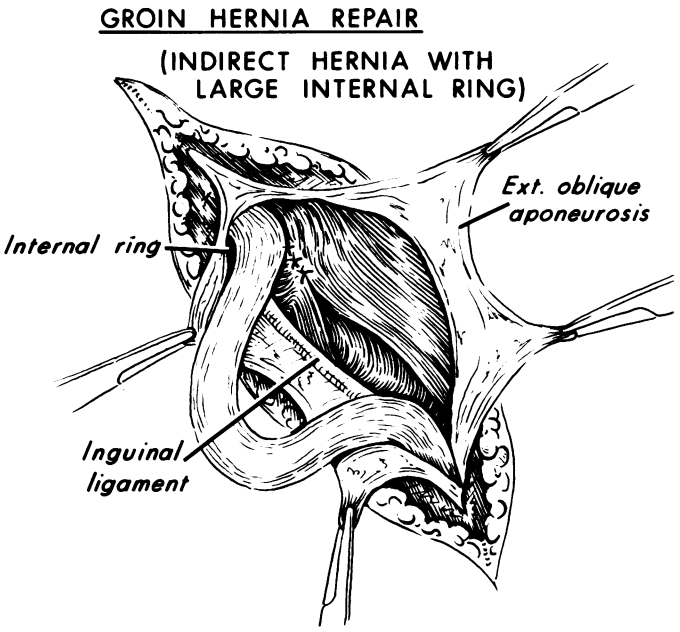

FIG. 4. Initial step in repair of indirect hernia followed by procedure illustrated in Fig. 6.

(group two) exhibited significantly lower ($P<0.01$) bursting pressures than did unwounded abdominal walls of sham-operated animals. However, from 7 days to 8 weeks postoperatively, wounds of Group 2 animals appeared stronger than did the normal abdominal wall of Group 1 animals.

Wounds which were repaired with the addition of an onlay graft of Mersilene® mesh (Group 3) exhibited significantly greater ($P<0.01$) bursting pressures at all time periods tested than did the wounds of animals repaired with Mersilene® suture alone. The superiority of the mesh (Group 3) compared to the suture alone (Group 2) appeared most apparent in the first postoperative week, when the former group was approximately two to three times stronger than the latter group. After postoperative day 7 and throughout the remainder of the test period, wounds of the animals in Group 3 were 50 to 60 per cent stronger than wounds of the animals in Group 2. After the eighth postoperative week, the majority (23 of 30) of abdominal wound disruptions in animals in Group 3 occurred through adjacent normal abdominal wall instead of through the wound. Only two out of 30 animals in Group 2 exhibited preferential disruption of the unwounded portion of the abdominal wall at these same time periods.

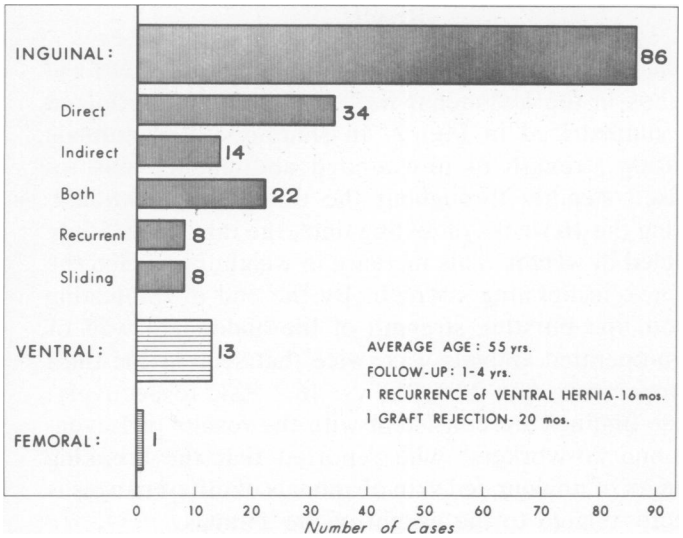

FIG. 3. Graph showing distribution of patients in which Mersilene® mesh was employed in repair of hernia.

Clinical Trial

For a 3½-year period ending in December 1973, Mersilene® mesh was used as an onlay graft in the repair of 100 hernias in adults. The average age of these patients was 55 years. Mersilene® mesh was selected because we considered it to have many favorable properties—it is readily available, inexpensive, soft, pliable, relatively inert, well tolerated by tissues, maintains good tensile strength, and does not unravel at the cut edges. This mesh was used as an adjunct to the hernioplasty in patients with: 1) large ventral hernias; 2) direct hernias resulting from severely attenuated transversalis fascia; 3) indirect hernias associated with a large internal ring and a weak posterior inguinal wall; or 4) combined direct and indirect hernias. Fig. 3 depicts the distribution of patients in which Mersilene® mesh was employed in the repair of

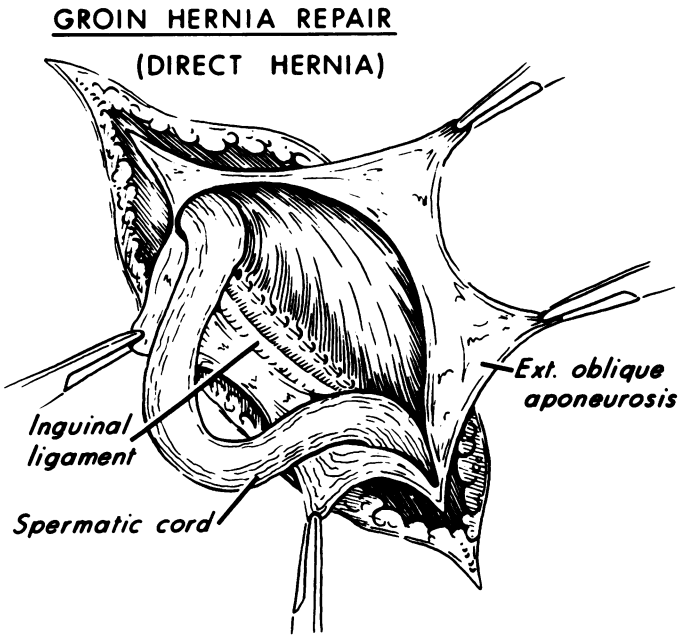

FIG. 5. Initial step in repair of direct hernia followed by procedure illustrated in Fig. 6.

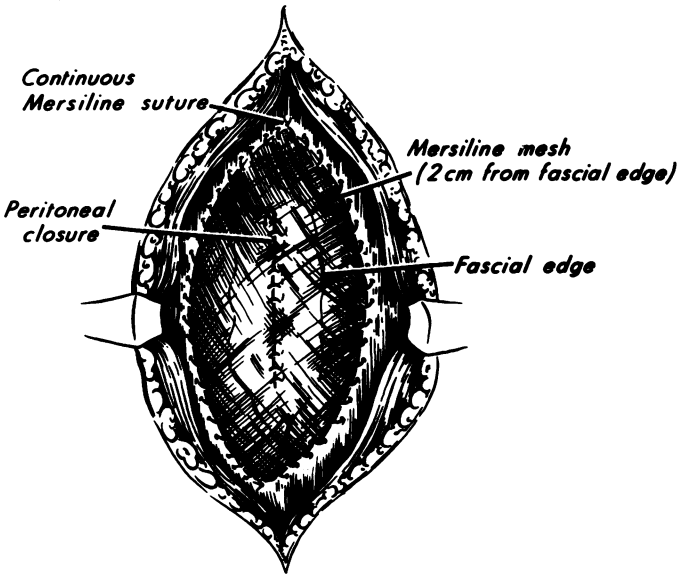

FIG. 7. Method used for repair of ventral hernia.

hernia. It also shows the relative frequency of its proportionate use in each type of hernia.

Technique of repair varied slightly depending on the anatomic defect and the choice of the surgeon. As a first step in repair of indirect hernia, the sac was ligated high, and the internal ring closed partially (Fig. 4). In repair of direct hernias, the sac was inverted and the transversalis fascia sutured over it (Fig. 5). In both types of groin hernia, the floor of the inguinal canal was then covered by an onlay graft of Mersilene® mesh sutured circumferentially in the following manner (Fig. 6): beginning at the pubic tubercle, the mesh was sutured sequentially to the conjoined tendon, lateral edge of the rectus sheath, internal oblique muscle, inguinal ligament circumscribing the internal ring, and finally to the pubic tubercle. Mersilene® or Prolene®* suture material was used throughout the procedures.

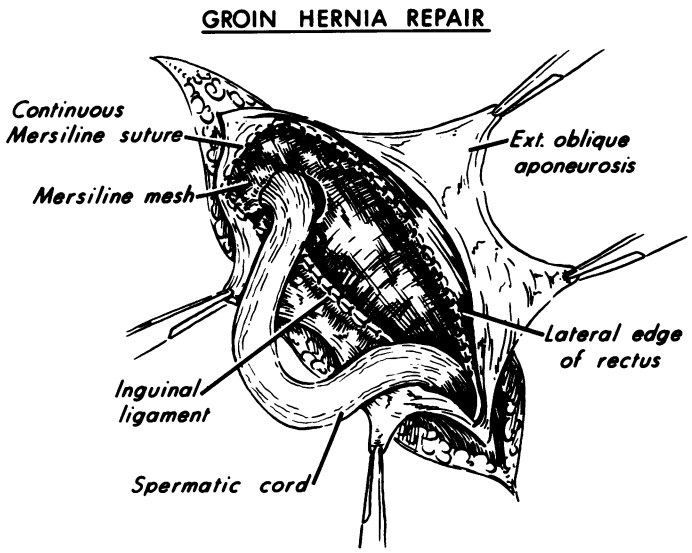

FIG. 6. Final steps in repair of groin hernia.

In the repair of ventral hernias (Fig. 7), the fascia was approximated, if possible, without undue tension. Otherwise, only the peritoneum or edges of the sac were closed, and the mesh was sutured in an onlay fashion over the defect. The mesh was cut so that it extended 2 cm beyond the fascial edge. Again only Mersilene® or Prolene® sutures were used. Suction with sump drains was used postoperatively in almost all cases of ventral hernia. Prophylactic antibiotics were not used unless a large amount of drainage was expected.

All patients were followed for a minimum of 1 year and a maximum of 4½ years. During this period there was one recurrence of a ventral hernia 16 months following repair. Only one serious complication consisting of recurrent abscesses and sinus formation occurred 20 months after operation. This patient had repair of a large sliding hernia of the groin which healed uneventfully and showed no evidence of infection for more than 1½ years. In this instance there was a past history of furuncles in the pubic area, and possibly the Mersilene® graft should not have been used.

Discussion

Our experimental and clinical investigations provide evidence that Mersilene® mesh can be used effectively in the treatment of difficult hernias with an acceptable rate

*Ethicon, Inc., Sommerville, New Jersey.

of complication. Our results of bursting strength in abdominal wounds of rats support the hypothesis that mesh adds to the strength of a healing wound. The added strength which the mesh provides would appear particularly important in the first 7 to 10 postoperative days when the most important factor contributing to strength of the wound is the suture material.[1] As shown in our study, the strength imparted by sutures alone in the early postoperative period is quite low and disruption of the wound in experimental animals occurred quite readily. After 10 to 12 days, the presence of sutures contributes little to the strength of the wound; the primary determinant of tensile strength is collagen deposition.[13] However, when local tissues are inadequate for repair of the wound, good fibroblastic proliferation is retarded and strength of the wound will continue to be low. Our data indicate that strength of the wound is markedly enhanced in these late periods by the addition of Mersilene® mesh. The reasons for this are twofold: 1) the mesh itself has good tensile strength and provides added support to a weak scar, and 2) the mesh initiates a tissue response with subsequent ingrowth of a dense infiltrate of fibrous tissue which contributes to strength of the wound.[16,18]

Our finding that a healing wound bursts at a higher pressure than unwounded abdominal wall is not a new observation. Several investigators have reported this result while testing the bursting strength of the abdominal wall of dogs[7] and guinea pigs.[1] Although we did not measure collagen content of the wounds, an explanation for the higher bursting pressure of wounded abdominal wall is that a healing wound has larger amounts of collagen by 14 days post wounding than does the uninjured tissue of the same type.

Despite the enhanced wound strength which was observed in the Mersilene®-mesh-treated group of our experimental model, it is difficult to extrapolate with any certainty the relationship between increased strength of the abdominal wall of the rat and prevention of recurrence of hernia in man. Furthermore, the true incidence of infection, erosion into adjacent tissue, or host rejection is difficult to evaluate in the rat model. However, it should be noted that throughout our experimental period, the group treated with mesh did not show an increase in these adverse reactions. Moreover, there are a group of rats which have had Mersilene® onlay grafts for over 11 months without untoward effects.

Although our clinical experience with the use of Mersilene® mesh as an onlay graft is admittedly small, the results to date have been gratifying. The rate of complication (1%) with the use of mesh has been quite acceptable and in accord with the rate of complication following routine herniorrhaphy which has been reported.[5] Moreover, the one infection which occurred in the present series was probably a result of an error in judgment since mesh was used in a patient with recurrent furunculosis of the groin. Using the technique described, the rate of recurrence has been 1 per cent inclusive for a followup period ranging from 1 to 4½ years.

Finally, it should be mentioned that Mersilene® mesh or other synthetic materials should not be used indiscriminately as a panacea for the "simple problem" of hernia. However, there are specific indications, as have been mentioned previously, in which the use of such mesh can result in a sound repair without any appreciable increase in the rate of complication.

Conclusions

In an experimental study in which Mersilene® mesh was tested against simple suture closure of abdominal wounds in rats, the wounds of the group treated with the mesh exhibited significantly greater ($P<0.01$) bursting strengths throughout the postoperative period.

Results of a clinical trial using Mersilene® mesh as an adjunct to the repair of hernia reveal a low rate of complication (1%) and a low rate of recurrence (1%).

Acknowledgment

We wish to express our appreciation to the Veterans Administration Hospital, New Orleans, Louisiana, for the use of its Surgical Research Laboratory where measurements of bursting strength were done. We also wish to express our appreciation to Touro Infirmary, New Orleans, Louisiana, for its generous financial support of the experimental study.

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Discussion

DR. ARLIE R. MANSBERGER, JR. (Augusta, Georgia): I rise not because I have a wide experience with respect to the use of synthetic materials, but, rather, have had the opportunity to study five patients who had massive abdominal wall defects, in which we utilized combinations of synthetic materials in timed sequence for repair. Three patients had abdominal wall defects to include peritoneum resulting from massive necrotizing infections, one was the result of trauma, and a third was secondary to resection of a tumor of the colon growing into the anterior abdominal wall.

(A motion picture was started.) The proposed technique shown here utilizes a combination of accepted surgical principles and techniques and is carried out in logical sequences as follows:

1. Repair of peritoneal defects with Silastic sheeting. Sterile wet dressings with physiologic solutions applied over the sheeting to minimize postoperative fluid loss until an endogenous (fibromesothelial membrane) forms beneath it.

2. Removal of the Silastic sheeting in 3-4 weeks of coverage of the endogenous membrane with full-thickness skin and subcutaneous tissue flaps to enhance sterilization of the granulation tissue.

3. Elevation of full-thickness flaps and repair of fascial defect with Marlex mesh. (This procedure carried out 6 to 8 weeks following successful skin coverage.)

It is interesting to note that in the experimental animal adhesions do not occur on the undersurface of the endogenous membrane which forms deep to the Silastic sheeting.

I would like to ask Dr. Cerise if he has used Mersilene in the repair of large, full thickness defects.

DR. M. BERT MYERS (New Orleans, Louisiana): I don't think that the mesh used by Dr. Cerise actually altered the biology of wound healing, as the fascial autograft in Dr. Peacock's work did. I think it merely acts as a mechanical support, much the way sutures do. Therefore, the type of mesh becomes important.

(Slide) Two meshes are available on the market; the mersilene mesh. which Dr. Cerise used, is made of Dacron, and the marlex mesh, which is polypropylene. We recently ran a series of rats using the marlex mesh, and found results very similar to Dr. Cerise. At three days, the wounds supported by marlex mesh were at least three times as strong as controls, whereas after a week all of the wounds were of equal strength. The difference, however, is in the mesh itself.

(Slide) This is a photomicrograph of the mersilene mesh, showing how it's braided, which is an advantage in that when it is cut it doesn't unravel. A photomicrograph of the cut edge, however, shows that it is made of many small filaments, which is its one disadvantage. There are many places where bacteria can lurk in this mesh, which happened in one of Dr. Cerise's patients, and late infection would be expected if these wounds should get infected.

On the other hand, marlex is a monofilament knit. The knit type mesh keeps it from unraveling; but each filament is a single strand of polypropylene, so late infection should be much less likely with this material, and we have had hernias get infected and not remove the marlex and have them heal.

DR. ASHER R. MCCOMB (San Antonio, Texas): I arise to offer some remembrances of the past and present and to congratulate Dr. Cerise and his co-workers on this fine contribution.

It was my pleasure to have worked with the late Dr. John E. Cannaday, a deceased member, who was the first in this country to use cutis grafts. Drs. Otto Lowe and Edouard Rehn, German surgeons, were the first to advocate using cutis grafts in the World War I era. During my association with Dr. Cannaday, we used cutis to repair all types of hernias and defects of various sorts. This proved to be a very satisfactory prosthesis, and, it was, we felt, the most satisfactory one available at that time.

Free fascial grafts, fascialata and various tissue transplants, such as the Bloodgood flap, are well known. The Bloodgood rectus fascia flap has been emphasized by another member, Dr. Rienhoff, Sr., and has been extensively used in inguinal hernia repair. We ran into hernias that were rather large to cover with fascia, and cutis graft has no limit as to how much you can take. It's always there. It cost nothing, except the time to cut the epidermis off and remove the cutis, and then use the epidermis to cover the defect.

While overseas during World War II, much appeared in the surgical literature about tantalum gauze mesh. On returning to practice it was discovered that Dr. Amos Koontz, a deceased member, had converted everyone to the use of tantalum, and I became a convert too. Then questions began to arise, such as, fragmentation of tantalum. Dr. Koontz, I remember, remarked, "Well it just acts as a form for fiberblasts to grow through, just like roses on a trellis. Actually, after a while the tantalum doesn't do anything but supply the form for formation of the scar which will hold the hernia intact."

Then along came a friend of mine from Houston, Dr. Francis Usher, who had developed and advocated marlex mesh. It was easier to handle than tantalum and was more appealing because of this. Later, the three of us were on a panel at a Texas State Medical Meeting. I was talked into using tantalum and marlex and haven't used cutis graft to any extent since then, but am seriously considering reverting to the use of cutis in selected cases.

In preparing a paper that was published in 1957 on cutis grafts, various and sundry materials that had been used and advocated as prosthesis in the repair of hernial defects were encountered in the literature. The number and variety of materials proposed was amazing.

We have encountered sad experiences with the use of both tantalum and marlex. I remember where tantalum was used in the repair of large epigastric hernias. The tantalum mesh fragmented and these patients came in several years later with abdominal abscesses which were felt due to perforation of the bowel by some of these fragments. These required drainage and later intestinal resection. Also, several complications occurred with marlex which supposedly were due to rejection phenomenon or allergy to this material since wound cultures were negative. One lady "spit" marlex fragments for nine years before clearing up. She was told that it wouldn't kill her. At the last A.S.C. meeting I saw a buttonhook contraption that I wished I had had to fish out some of these strands, because marlex is the devil to get out. We even went back in and tried to take some of this out, with little success.

It is to be recalled that Dr. Amos Koontz frequently stated, very emphatically, that he wouldn't do a hernia under general anesthesia. That a lot of hernias recurred in the recovery room fighting their way out of the anesthesia. We have all experienced this and one could almost see the sutures pulling out as the patient struggled with four recovery room attendants trying to hold him down. Perhaps we should find out preoperatively how these patients react to alcohol: whether they are "fighting drunks" or "crying drunks."

I prefer spinal anesthesia for herniorrhaphy, but it is difficult to get an anesthetist to administer spinal any more because of the medicolegal hazards. Recently I was impressed by Lichtenstein's work on repairing inguinal hernias under local anesthesia. Our friend and fellow member, Bill Lorimer, presented a paper before the Texas Surgical Society on the repair of a tremendous ventral hernia under local anesthesia. He gave several times the recommended dose of Lidocaine to repair this. The patient survived and made a good recovery. So I think that "peace and tranquility" of the abdominal wall enhances adequate healing. I would like to bring these few points to your attention.

I might add that, after cutis, full thickness skin graft was used. Later, objections were raised that cyst formation occurred. We did not experience this with cutis graft.