Subcutaneous Extraperitoneal Repair of Ventral Hernias:

A Biological Basis for Fascial Transplantation

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Two fundamental biological differences between normal fascia and scar tissue are rate of collagen turnover and physical weave of collagen subunits. Both factors account for unsatisfactory results following ventral hernia repair unless scar tissue is excised and normal fascia used. Removal of scar and identification of normal fascia often require extensive dissection, entrance into the peritoneal cavity, and sometimes requires lysis of intestinal adhesions with occasional injury to bowel. Simple imbrication of the hernia sac, as in treatment of a direct inguinal hernia, without extensive scar excision usually results in recurrence of the hernia because of remodeling and attenuation of scar tissue. A new procedure, based upon the technique of direct inguinal hernia repair without opening peritoneum, has been performed on 12 patients with large ventral hernias. The procedure, performed entirely in a subcutaneous plane, involves imbrication of scar, transfer of a massive fascial onlay graft, and use of an internal stent. Patients have been followed for one to 5 years; there have been no recurrences. Inductive influence of the fascial transplant has been measured in two patients; a tenfold increase in net collagen synthesis and deposition occurs for at least one year following transplantation of fascia to an imbricated scar recipient area.

FASCIAL GRAFTS have been used in a variety of ways to reconstruct the abdominal wall. McArthur, Gallie, and Le Mesurier pioneered the use of fascial strips as biological sutures.[5,8] Kirschner introduced the use of sheets of fascia to increase breaking strength of the repaired abdominal wall; Wangensteen used the distal portion of the tensor fascia lata as a pedicle graft with intact proximal blood and nerve supply to reconstruct inguinal and inferior abdominal wall defects.[6,18] Modern surgeons, however, with the exception of a few such as Ravitch, have seemed less interested in biological grafts and more intrigued with artificial substances such as Marlex, tantalum and nylon—presumably because of ease of procurement.[7,10,15,16] There seems to have been little interest in developing the use of biological grafts during the past two decades. Because artificial substances become fragmented with time and occasionally have to be removed, fascial grafts should not be discarded entirely, particularly if indications for using fascial grafts can be expanded and repair of abdominal hernias made less difficult. Recent studies in transplantation and wound healing biology have suggested theoretical advantages and technical modifications for the use of fascial transplants based upon biophysical and biochemical differences between naturally woven dense connective tissue and scar.[7] The rationale for such modifications follows.

One of the striking differences between dense connective tissue synthesized and remodeled during healing of a wound and dense connective tissue found naturally in fascia and tendon is reaction or response to physical stress. Although there are exceptions such as surface scars in the pectoral region or upper extremity of young people, scar tissue predictably responds to physical stress by becoming thin and elongated.[1] With the exception of frank keloid and hypertrophic scar which are rare in the abdomen and lower extremities, scar tissue in the lower half of the body becomes attenuated and thin with passage of time and application of stress, In contrast, naturally occurring dense connective tissue such as fascia and tendon resist physical stress and may even become hypertrophic rather than attenuated.[2,11] The mechanism of attenuation of scar tissue is not understood completely but probably involves longitudinal slipping of subunits; attenuation also may be the result of less than optimum physical weave and biochemical cross-linking during secondary remodeling. Naturally occuring dense

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connective tissue, such as that found in fascia or tendon, seems ideally oriented and woven to resist longitudinal slipping of fibers and fibrils and may even be molecularly organized to insure maximum inter- and intramolecular cross linking.

Another factor worthy of consideration for the reconstructive surgeon may be the nearly tenfold acceleration of rate of net collagen synthesis and deposition measured in fascial grafts following autogenous as well as allogeneic transfer.[9] In this respect, free fascial grafts may be even more biologically active in the induction of collagen synthesis and deposition than a pedicle flap which has not been completely severed from nerve and blood supply. Consideration of fascia lata as a membrane internally organized to resist physical stress and biologically active in the induction of collagen synthesis and deposition adds a new dimension to the use of fascial grafts during repair of ventral hernias. Specifically, if a fascial transplant provides early mechanical support and late biological inductive control of synthesis and secondary remodeling of connective tissue, the repair of a ventral hernia could be accomplished in a subcutaneous plane similar to repair of a large direct inguinal hernia without opening the peritoneum. Following this line of reasoning, fascial grafts could be used as biological inductors and temporary splints to make the repair of *all* abdominal hernias technically easier and recurrence less frequent rather than using the grafts almost entirely as a substitute for missing fascia in large defects, as previously recommended.

Most surgeons agree that the major technical difficulty in repairing a ventral hernia is accurate identification of normal tissue.[14] The center of the defect usually is a combination of subcutaneous fat, attenuated scar tissue, and underlying peritoneum. Simple imbrication of scar tissue and peritoneum invariably results in recurrence of a hernia unless imbricating sutures are placed lateral to scar tissue in naturally woven normal fascia. Surgical dissection of the hernia and identification of normal tissue in the lateral margins are important steps, therefore, in successful repair of ventral hernias by conventional means. In most hernias, it is necessary to open the peritoneum and dissect the full thickness of the abdominal wall in a lateral direction until normal fascia is encountered. Failure to make an accurate distinction between lateral scar tissue and normal abdominal fascia often causes the surgeon to repair the defect with wound repair tissue and practically assures attenuation and recurrence. This often repeated principle of hernia repair is relatively easy to expound but technically may involve several hours of fairly hard work, particularly if intestinal adhesions are encountered.

An alternative to opening the peritoneum and searching for normal fascial margins is based upon exploitation of physical and biochemical properties of fascia lata rather than abdominal wall surgery. Considered in this way, advantages of fascial grafts are equally applicable to small and large defects as the hernia is virtually ignored and the critical tissue junction is lateral to the defect between superficial normal fascia and graft rather than between two dissected surfaces of the abdominal wall. Practical advantages of overgrafting an imbricated hernia are that dissection is easy because it is limited to a subcutaneous plane lateral to scar tissue and intra-abdominal complications can be reduced or eliminated because the peritoneum is not opened. Obviously, such advantages will be appreciated more when repairing large defects than during repair of a small hernia. If recurrence is less or even no worse than following conventional methods of repair, disadvantages of using a fascial graft for all repairs should be limited to procurement of the graft. The theoretical and practical advantages and disadvantages of fascial grafts used following simple imbrication of a ventral hernia to provide temporary structural strength and long-term biological induction of collagen synthesis and deposition have been studied in 17 patients. Six of the patients had two or more recurrences following repair by a competent surgeon.

Technique

The operative procedure consists of opening the previous cutaneous scar and reflecting lateral skin flaps to expose the lateral abdominal wall. Cutaneous scar should be incised, not excised, unless the scar also is thin and attenuated. For a long period of time, biochemical and biophysical conditions measured within a cutaneous scar seem superior to normal skin, as far as subsequent or secondary healing is concerned. After the skin flaps have been reflected, subcutaneous dissection is performed to expose normal abdominal fascia several centimeters lateral to the hernia. A ring of normal fascia surrounding the abdominal defect should be exposed by this maneuver. Exposure of normal fascia should be so far lateral to the central defect that there is no question about being external to the zone of attenuated scar. The regular right angle weave of shiny white fiber bundles identifies normal fascia accurately. The hernia sac is then imbricated with large non-absorbable sutures to produce normal contour of the abdominal wall (Fig. 1) Sutures should be placed far enough lateral to imbricate the hernia sac neatly but not so far lateral that significant tension is produced when the sutures are tied. No attempt should be made to place the sutures in normal fascia if doing so produces tension. The purpose of the imbricating sutures is to reduce the hernia and restore normal contour to the abdominal wall; in small defects it may be possible to place imbricating sutures in normal fascia without producing significant tension. If the repair of large hernias is stopped after imbrication of the sac, recurrence will take only a few days or weeks as most of the sutures probably

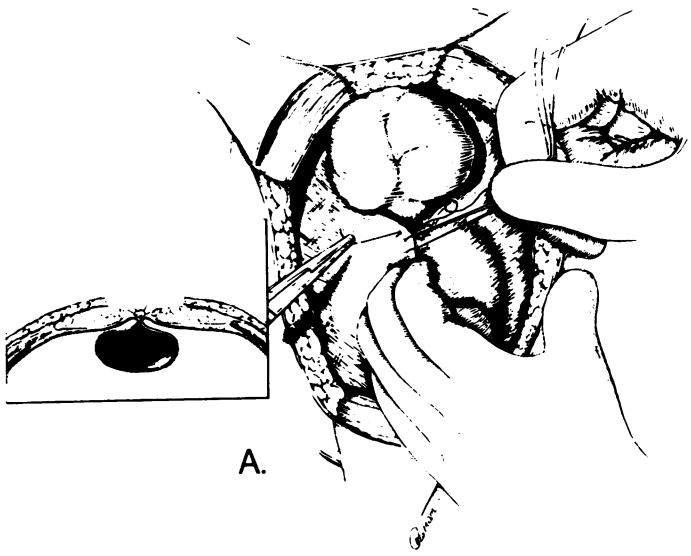

FIG. 1. Imbrication of central scar tissue to reduce peritoneal sac and restore normal contour of abdominal wall. In larger hernias, sutures will be in attenuated scar; in small hernias, sutures will be placed in normal fascia without producing significant tension.

will be in junctional scar tissue which will attenuate or tear when the stress of abdominal muscle contraction occurs.

After the abdominal wall has been contoured by imbricating sutures, an onlay fascia lata graft is applied for the reasons outlined above. The graft is removed from the thigh through either a curved longitudinal incision or two transverse incisions. The sheet of fascia is applied to the abdominal wall as an onlay skin graft would be sutured to a surface defect. (Fig. 2). Relatively large nonabsorbable sutures, such as #2-0 silk, are used to attach

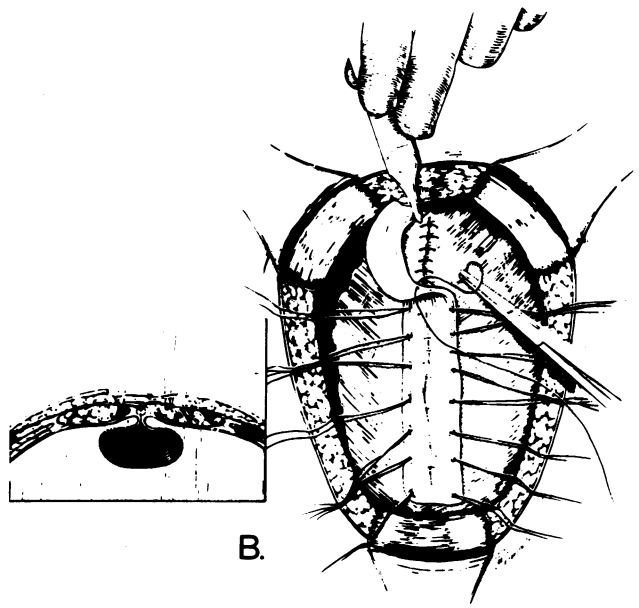

FIG. 2. Application of free fascia lata graft over imbricating sutures. The lateral sutures in graft must be placed in normal fascia.

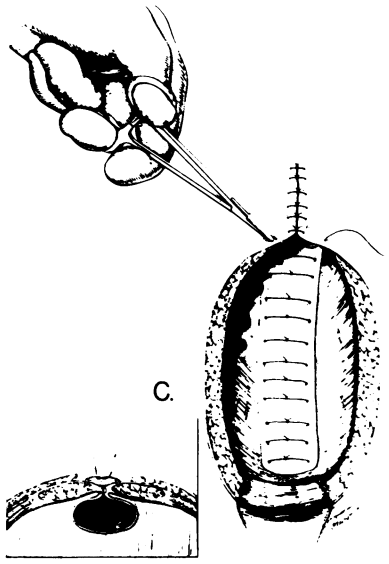

FIG. 3. Lateral sutures are tied across graft as in a stent fixation of a skin graft. Tying sutures across the graft helps obliterate dead space and provides mechanical support during healing.

the graft to the ring of exposed fascia surrounding the imbricated hernia sac. The ends of the sutures are retained to tie across the graft as in a stent fixation of a skin graft. Tying the sutures across the graft provides additional mechanical strength independent of the graft during the period of revascularization and early healing (Fig. 3) Finally, the skin flaps are reapproximated over the graft; hemovac suction has been used for 24 hours following repair of large hernias. A snug, but not constricting, abdominal binder has been used to obliterate space in the subcutaneous tissue following repair of small hernias or for a few days after removal of the hemovac tubes following repair of large hernias. The area of subcutaneous dissection is relatively large and collection of serum will occur if some measure is not taken to obliterate space and splint the skin flaps to the body wall during early healing.

The donor wound in the thigh is closed and a Penrose drain is inserted or a hemovac drain utilized to prevent accumulation of serum.

Results

The 17 patients in this series receiving onlay fascia lata grafts after imbrication of a ventral hernia sac have been followed between 2 and 5 years. There have been no recurrences in the area of the graft. One patient was found to have a small ventral hernia 12 months following repair with a fascial graft and was explored through the same incision. The graft could be clearly identified (Fig. 4); the hernia sac was 2 cm inferior to the margin of the graft. The conclusions were that the previous surgeon had misjudged the inferior extent of the defect at the time the graft was transplanted or that a progressive degeneration of the abdominal wall had occurred inferior to the grafted area. There was no indication that the graft had disintegrated.

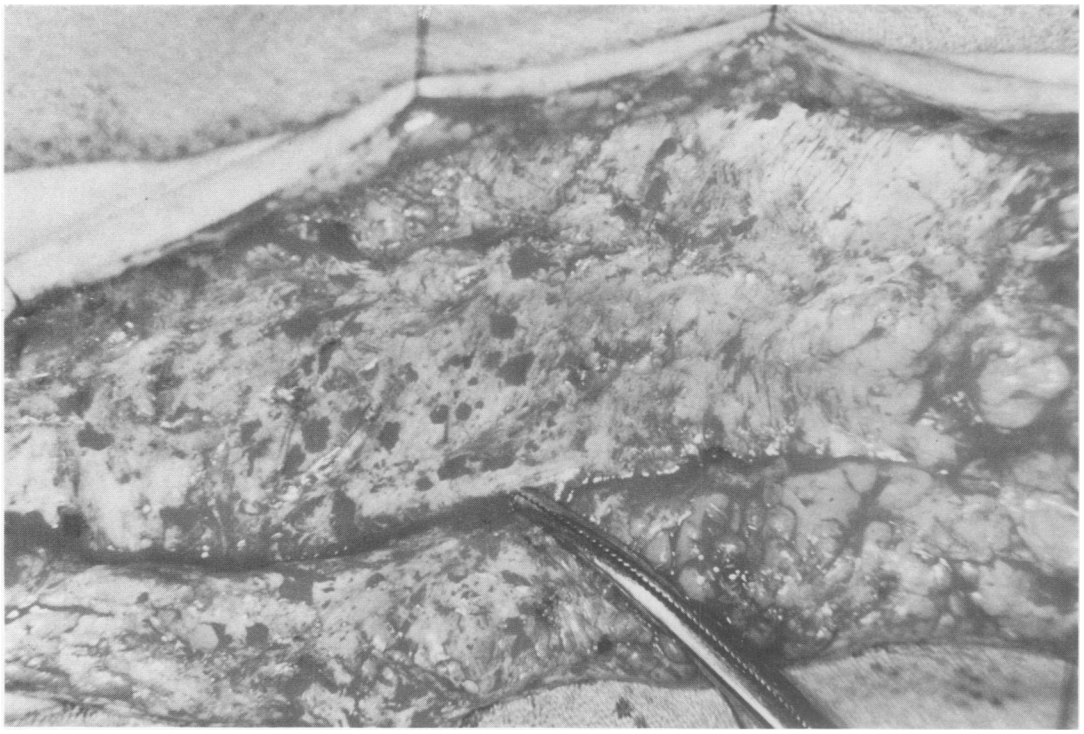

FIG. 4. Fascial graft placed over imbricated suture line two years previously. Note that graft edge (at end of hemostat) can be easily identified. Sutures tied across graft are permanently enmeshed in scar and graft.

Two grafts have been exposed approximately one year following transplantation. One graft was in the patient described above with an inferior hernia; the other patient developed a renal tumor and was operated upon through a flank incision which was extended medially and superiorly to expose the graft. Both grafts were grossly discernible and did not appear to have changed in any significant manner. The stent fixation was firmly imbedded in new scar over the surface of the graft. The right angle weave of the original fiber bundles could be identified and did not appear to have been changed by transplantation. In one patient it was possible to compare total collagen and net rate of collagen synthesis and deposition in the graft before and after transplantation. Similar studies were performed in the other patient at the time of re-exploration; unfortunately, pretransplant studies were not performed in this patient and so comparison of the rate of synthesis before and after transplantation was not possible. In the patient in whom pretransplant data were available, net collagen synthesis and deposition was measured by the Peterkofsky-Diegelman method and reported as specific activity in disintegrations per minute per microgram of hydroxyproline.[13] Pretransplant studies of the fascia lata showed 11.0 disintegrations per minute; one year later the graft showed 91.0 disintegrations per minute or a ninefold increase in rate of collagen synthesis and deposition. Total collagen in the specimens was measured by the Woessner technique.[20] The graft showed 12.258 micrograms of hydroxyproline per milligram dry weight of tissue before transplantation; one year later the graft had 8.426 micrograms of hydroxyproline per milligram of dry weight of tissue. This finding strongly suggests that collagenolytic enzyme activity kinetics also were accelerated and that turnover of collagen in the fascia was increased following transplantation. The graft from the other patient showed 90.0 disintegrations per minute when analyzed for net collagen synthesis and deposition. Because pretransplant values for normal fascia on all specimens averaged approximately 10 disintegrations per minute, it seems likely that a significant increase in net collagen synthesis and depostion occurred in the second patient as well. Total collagen in this patient was 7.432 micrograms of hydroxyproline per milligram dry weight of tissue; the average total hydroxyproline value in pretransplant fascia is 8.426 micrograms of hydroxyproline per milligram of tissue. Thus a small reduction in total collagen appears to have occurred in this patient also. These measurements in patients reveal almost exactly the same findings as previously reported in fascial transplants under similar conditions in animals.[9] Pre- and post-transplant electron micrographs of one fascial graft revealed preservation of the original parallel orientation of fibrils. Coarse fiber bundles also appeared by gross observation to have retained their original right angle weave.

None of the patients developed significant or prolonged donor site problems; the first 5 patients developed transient collections of serum which required drainage during the early postoperative period. Subsequent use of hemovac drains or penrose drains has seemed to eliminate this complication. There were no late sequelae in the donor site and none of the patients reported any disability

following removal of their tensor fascia lata. The two most serious postoperative complications were respiratory in one patient who had the lower chest immobilized by a constrictive dressing applied too high on the thorax, and drainage of the abdominal wound for several months requiring removal of an infected suture in another. In the patient with the infected suture, the graft was not affected and the hernia repair remained intact.

Operating time averaged one and a half hours with a minimum of 45 minutes and a maximum of two and a half hours. Abdominal distension, ileus, or other gastrointestinal complications were not observed in any of the patients.

Discussion

Two obvious objections to the use of a large fascial onlay graft and stent fixation to bolster an inadequate ventral hernia repair consisting only of imbrication of the peritoneal sac and scar are 1) production of a donor site wound in the thigh and 2) insertion of a relatively large amount of non-absorbable suture material. Other than a few minutes of extra operating time required to take the graft, the donor site complications can be dismissed. In a superb study of 57 patients followed from one to three and a half years after removal of large sheets of fascia lata, Dubiel and Wigren searched for disability which could be measured in the donor extremity.[4] There simply was no disability in their patients and there was no disability in the patients reported in this paper. Moreover, recent studies comparing certain biochemical and biophysical effects of transplanting autogenous and allogeneic grafts reveal that, under the conditions of the experiments, there was no significant differences between allografts and autografts.[9] If a reason exists, therefore, not to take an autograft, it seems likely from these studies that an allograft would perform equally well.

Because many ventral hernias are the result of abdominal wall infection, the objection to the use of stent fixation of the graft because of the relatively large amount of non-absorbable sutures required is more than theoretical.[3] One of the patients in this series required removal of an infected suture. Because the graft apparently was not affected, however, it does not seem now that this complication is a serious deterrent to the use of an onlay fascial graft with stent fixation. Because a new fascia lata transplant does not have great tensile strength in all dimensions, and because preliminary imbrication is almost worthless from the standpoint of resistance to physical stress, a strong non-absorbable suture technique was thought to be worthwhile in providing physical strength during the first 3 to 4 weeks while the graft is becoming a part of the anterior abdominal wall. In some respects, the stent fixation acts as an ethylon mesh repair while the graft becomes attached to the abdominal wall and underlying central scar tissue. Since developing this technique, the author has learned that Ravitch has recommended using fascial onlay grafts over peritoneal imbrications without stent fixation.[15] Perhaps the stent fixation is unnecessary.

Practically every conceivable material has been used successfully and unsuccessfully to replace missing abdominal wall or bolster a repair consisting of direct approximation of the edges of a fascial defect. There has been recurrence following all types of repairs—a finding which supports experimental work and observations in human patients suggesting that a major connective tissue abnormality is present in some, if not all, recurrent abdominal and inguinal hernias previously repaired by competent surgeons.[12,17,19] In patients where this is true, and it should be considered in all patients where recurrence follows repair by an adequate surgeon, a biologically active substance may offer advantages over artificial or inert materials. That fascia is such a biologically active membrane and that activity in the transplant is increased significantly by autogenous and allogeneic transplantation suggest theoretical advantages to the use of fascia over non-biological substances. Application of the graft through a subcutaneous plane without opening the peritoneum is attractive from the standpoint of reducing operative time and postoperative gastrointestinal complications. The results in the patients reported in this paper indicate that theoretical advantages pertaining to the inductive power of transplanted fascia are accompanied by practical advantages measured in terms of persistence of the repair, reduction of complications, and elimination of some technical difficulties. The procedure is recommended, therefore, on the basis of practical as well as theoretical advantages in the repair of ventral hernias of any size. Primary repair of a small hernia may be an exception but recurrent hernias of any size following repair by a competent surgeon probably represent some sort of local or general connective tissue abnormality and should, therefore, be considered for repair using biological as well as mechanical adjuvants.

Conclusion

Autogenous grafts of large sheets of fascia lata applied by a stent technique over imbricated scar and peritoneum offer theoretical biological and practical technical advantages when compared with non-biological substitutes.

Seventeen patients operated upon by the onlay-imbrication technique have not developed recurrences over a 2 to 5 year observation period and did not develop any significant postoperative gastrointestinal complications.

The use of relatively large amounts of non-absorbable suture material in a wound which has a high incidence of retained organisms appears at this time to be the major theoretical hazard of the procedure. In one patient in this

series, removal of an infected suture did not result in loss of the graft or recurrence of the hernia.

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Discussion

Dr. Ashbel C. Williams (Jacksonville, Florida): I gave a paper many years ago before this organization at the time I was taken in. The subject was fascial transplants after the method of Dr. Edward Gallie. This was the last paper on the last day of the meeting. As I recall, Dr. Amos Koontz, Joe Hamilton and Calvin Klopp were the only ones considerate enough and loyal enough to stay and listen to it.

At that time I reported 54 inguinal hernias repaired with living fascia after the method of Dr. Gallie. I had talked with Dr. Gallie over the phone and had several letters from him prior to that time and ascertained that he still was completely sold on the method as he had originally presented it. This, I think, was in 1955.

Since that time I have had approximately 50 additional Gallie operations and to my knowledge there have been only three recurrences.

This operation has been done only on patients who had had hernia repairs previously or who had had huge hernias and were in very demanding physical lines of work where they were subjected to all types of stresses and strains.

At the time of the original paper I had followed some patients as long as 12 years postoperatively and quite a few of the original group have departed this earth because of age or other diseases, but only three, that I know of, have had recurrences of their hernia.

I have not been aware of all the erudite things that Erle Peacock has told us about what happens in the cellular compartments, etc., but I feel strongly that this fascial repair is the Cadillac of all hernia repairs.

After a brief experience with tantalum mesh in inguinal hernias, I gave this method up because the repairs were painful and if there was a recurrence the difficulty of correcting it was formidable.

On incisional abdominal hernias I use stainless steel or tantalum mesh and have been very impressed with the effectiveness and durability. I am sure, however, that fascia would do very well in these abdominal hernias, as it does in the groin. But the comfort in the groin of the fascia repair is not comparable with anything that I was able to accomplish with mesh. Some of the repairs encompass such a large area that I feel here that mesh would probably be preferable.

Dr. Robert Zeppa (Miami, Florida): When Dr. Peacock speaks, I always learn something; but I remember calling him about a year ago about a problem with recurrent inguinal hernia. I had first occasion to see this gentleman for his third or fourth hernia repair and discovered that the first three had not been done to Cooper's ligament. So we did a Copper's ligament repair, and six months later it was back.

That exhausted my therapeutic efficacy, so I called Erle, and he suggested putting in a large fascial autograft through the Cheatle Henry approach, which we did, which lasted six or eight months. On return to this inguinal area, no fascialata could be found, back to the peritoneum.

My question is this: Are there patients who have collagenolytic activity such that the application of fascialata, or other fascias, would be precluded because of their capability of dissolution, rather than the excitation of normal human collagen induced by such a graft? Thank you.

Dr. Erle E. Peacock, Jr. (Closing discussion): Bob, you always get right to the point. That's one of the things we're studying: Can the graft get the disease, just like a transplanted kidney? Can it get glomerulonephritis and ruin the whole technical procedure?

This is premature for me to answer, though I promise you, within the next few years, enough data, I think, to help answer it. But I will say this now. We have two such patients such as yours. I think the groin situation is an entirely different matter, and collagenolytic activity in the groin is fierce. We have measured it, and it's fierce.

In the two patients in which we got recurrence from a massive graft, we were able to find that graft mechanically dislodged, rolled up, and it was due to the graft moving out of place. I couldn't find any evidence that the graft had actually gotten the disease, like the transversalis fascia did; and that's when we started to put it in like an aeroplane wing, from one lateral pelvic wall to the tip of the sacrum, to the symphysis pubis, across to the other wall, in a preperitoneal approach. But that's another subject.

With your permission, I'd just like to say that you asked just the question, and I promise that we will have some data that will satisfy you, both biochemically and mechanically; but now to say that I just really can't identify a patient who destroys a fascial graft that fast, and yours may be one that I wish was in my series, but we're bound to find one sooner or later like that if we keep looking and studying.