

THE REPAIR OF ABDOMINAL INCISIONS

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WOUND repair and wound healing are a constant problem in surgery. The surgeon makes incisions in the abdomen more than in any other region. He should be concerned with the best methods of repairing these wounds. Every thoughtful surgeon is interested in the processes that insure the optimum healing and restoration of the abdominal wall to as nearly normal as possible.

With all the importance of this subject and the general interest of surgeons in their daily dealing with it, there is an astonishing dearth of accurate description of the technic of abdominal wound closure as compared with the repair of other wounds, especially of a plastic nature. William S. Halsted,¹ in his epoch making paper in 1913, in which he presented the silk technic and its essential philosophy which he had developed at the Johns Hopkins Hospital, devotes only a short paragraph to the discussion of abdominal wound repair, but gives no details as to type of suture and method employed.

In 1932, Dr. Arthur Dean Bevan² presented a paper before the American Surgical Association entitled "Abdominal Incisions and Their Closure." In this paper special stress was laid on the description of various incisions, and emphasis was placed on the closure, giving the details of a technic worked out by himself at the Presbyterian Hospital, in which retention sutures of silkworm gut were tied over pearl buttons. No definite figures were quoted, however, relative to the percentage of wound disruption and of postoperative ventral hernia following closure of these various incisions, but in other respects this is a most comprehensive discussion of the subject of abdominal incisions.

It is only in recent years that the frank and honest discussion of wound infection and abdominal wound disruption, as a result of the study of carefully recorded and analyzed hospital records in our best hospitals, has revived an interest in wound healing.

The repair of abdominal incisions presents particular problems that are not met with in other wounds or other regions. These may be analyzed under the following headings:

(1) The peculiar arrangement of the flexing and rotating muscles, and the aponeurotic layers entering into the complex functions of the muscles of the abdominal wall (Figs. 1, 2, and 3). The lateral pull of the oblique and transversalis muscles on the outer edges of vertical incisions is an almost daily, distressing observation in the closure of such wounds.

(2) The repaired abdominal incisions, especially those in the upper abdomen, are subject to peculiar stress and strain as a result of vomiting, coughing, hiccough, distention and the lifting and moving of the patient by the

attendants in the administrations consequent to the many daily physiologic demands and in nursing care. The sudden pain associated with the above factors increases the lateral pull of the rotating muscles, and increases intra-abdominal tension.

(3) The abdominal incisions are more frequently contaminated with virulent and necrotizing aerobic and anaerobic organisms than any others.

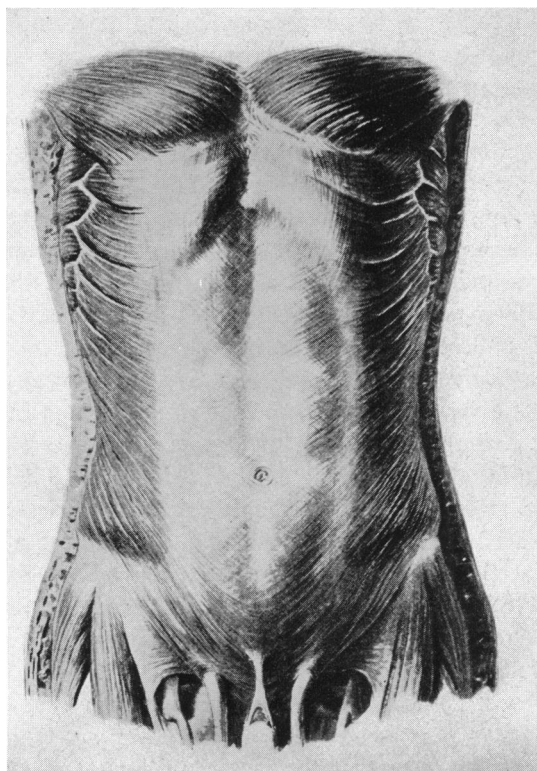


FIG. 1.—To show direction of muscle and aponeurotic fibers of superficial abdominal muscles. (From Spalteholz, 2nd edition.)

Activated enzymes are at times in contact with drained incisions in patients requiring intestinal repair, followed by fistulae. These are factors which not only inhibit normal wound healing but may actually digest the tissues and dissolve the absorbable catgut sutures used in the repair. In such wounds the factors of increased intra-abdominal tension are most often associated, and it is in these patients that wound disruption and ventral hernia are most frequently seen.

(4) In many elderly or cachectic patients suffering from prolonged malnutrition and vitamin deficiencies, and requiring extensive operations for resections of malignant growths of the gastro-intestinal tract, the low serum protein content of the blood and the tissues prevents normal healing and unquestionably predisposes to wound disruption.

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(5) Because of the dread of the factors mentioned under the above headings, many surgeons believe that heavy suture material should be employed both in the layer repair and in the tension or reinforcing sutures. Heavy chromic catgut, in double strands, as high as No. 2 grade, is used in many clinics. One has but to watch the inexperienced house surgeon or assistant pull up on these continuous sutures, or the heavy silkworm gut or metal re-

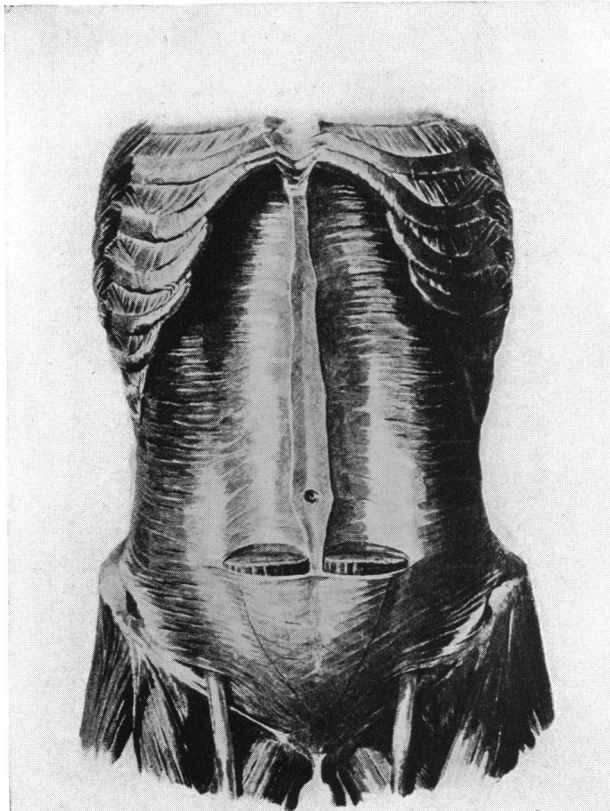


FIG. 2.—To show direction of muscle and aponeurotic fibers of deeper abdominal layers. (From Spalteholz, 2nd edition.)

inforcing sutures, to appreciate the amount of tissue necrosis that will inevitably result within the following 24 hours. A study of microscopic sections in wounds so repaired reveals long transverse lines of tissue necrosis on either side of the repaired incision (Figs. 4 and 5). The necrosis takes place until the tension between suture and tissue is relieved. This tension, with a running continuous tight suture, diminishes the blood supply to the very tissues in which the surgeon is attempting to encourage wound healing. This mistake of tight suturing is probably the most common one made in the repair of abdominal incisions.

Because of the fear of wound infection, and persistent sinus formation resulting from employment of nonabsorbable sutures, catgut is used by the

majority of surgeons in abdominal work. In wounds contaminated with lower ileal and colon contents, nonabsorbable sutures should not be used; but in such wounds, contaminated with necrotizing organisms, and in incisions where activated pancreatic ferments are apt to be secreted, as in duodenal, jejunal and pancreatic operations, catgut has very definite drawbacks. The irregular and early absorption of both plain and chromic catgut sutures in

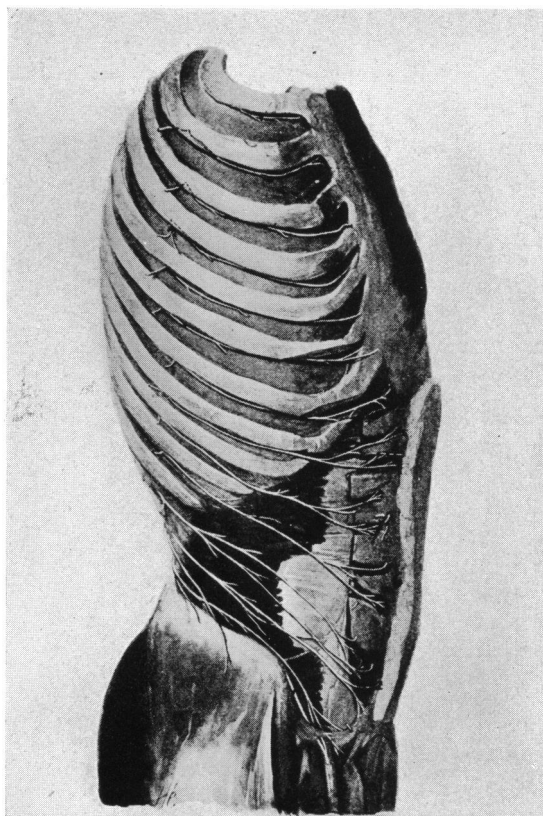


FIG. 3.—To show direction and distribution of nerves to abdominal wall. (From Spalteholz, 2nd edition.)

the presence of intestinal ferments has been noted by every experienced surgeon and has been experimentally demonstrated.³ Another factor, which has only within recent years been pointed out,^{4, 5} is the allergic reaction of catgut in patients showing edema of the wound edges and in disruption of abdominal wounds. Kraissl,⁴ working in our Surgical Laboratory, sensitized 52 guinea-pigs to plain and chromic catgut. Celiotomies were performed upon these animals. Thirty per cent of these guinea-pigs disrupted their abdominal wounds. All of a series of 26 control guinea-pigs healed normally except one. There is little doubt but that the local reaction in patients allergic to catgut predisposes to infection and favors wound disruption.

Contaminated Incisions With and Without Abscess.—In abdominal incisions contaminated with ileal and colon contents our present technic is as follows: If an abscess, as in appendicitis, is present, it is drained with one or

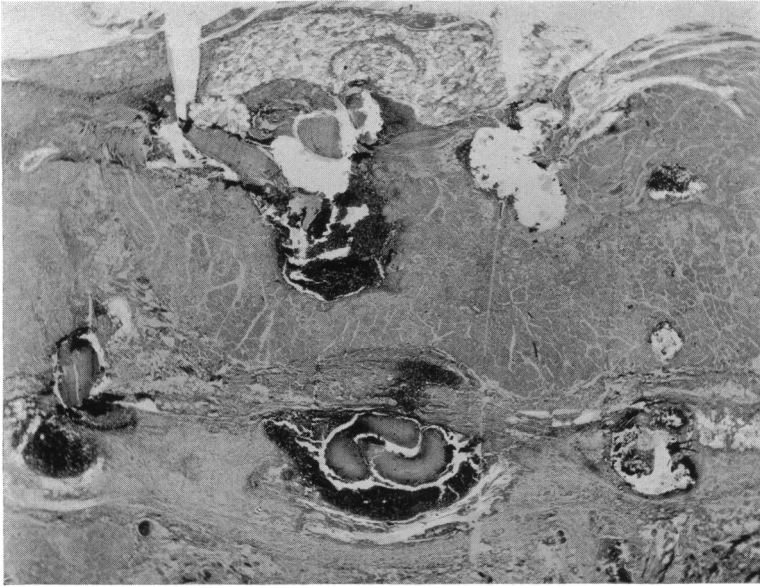


FIG. 4.—(Two day wound.) There is a moderate amount of cellular infiltration around the catgut sutures, thick, swollen strands of which are seen to the left surrounded by exudate. On the right side are seen the silk sutures surrounded by practically no exudate. Fibroblasts and granulation tissue are already evident around both catgut and silk sutures. Repair has already started.

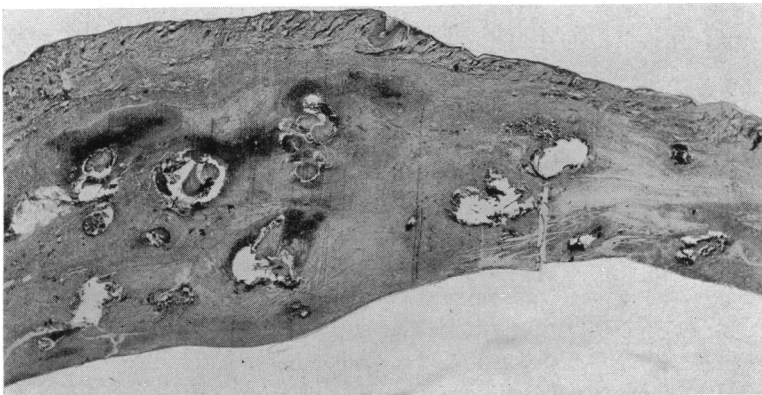


FIG. 5.—(Six day wound, catgut on the left side, silk on the right side.) All silk fibers are separated by an ingrowth of fibroblasts and giant cells. In striking contrast, there is no growth immediately around the catgut, which is surrounded first by a pool of exudate, then degenerated muscle, and then by granulation tissue on the outside of this. This is a very striking contrast. Note the difference in the thickness of the wall on the catgut and silk side, due to excessive edema of the tissues where catgut was used.

two soft rubber tubes or cigarette drains, introduced through a small opening in a China silk tampon, the peritoneum is closed with interrupted No. 00

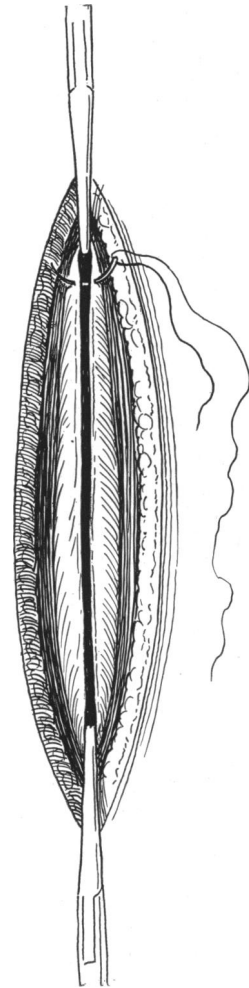
chromic catgut sutures around the drains, and the wound is then packed with weak iodoform or zinc peroxide gauze around the drains inside the silk tampon. No attempt is made to suture the muscles, subcutaneous tissues or skin. The patient must be kept in bed longer than the ones with sutured wounds, until the wound has filled in with granulation tissue.

If an abscess is not present but the wound edges are contaminated with ileal or colon contents, as in an open resection, a small Penrose drain is placed near the site of repaired intestine, the peritoneum is closed about it, and at least the central part of the wound is tamponed as in the case of the abscess.

Clean Abdominal Wound Repair.—We tend, more and more, to employ fine silk in all abdominal work. Frequently the hemostats are left on until the lesion in the abdomen is revealed, when either catgut or silk can be decided upon. They should not be used together, as it has been demonstrated⁶ that catgut favors the growth of bacteria in the wound; and in an infected wound, silk, unless in very fine grades, is more apt to act as a foreign body and cause protracted sinuses. The only abdominal wounds not associated with abscesses that we drain now are resections for gastric and colon cancers, cholecystectomies, especially where the cystic duct stump is not adequately peritonealized, and common duct drainages.

In upper abdominal operations we determine the type of incision largely by the width of the intercostal angle—using the transverse for the wide-angled, obese patient, and the split rectus for the narrow costal-angled, thin individual. We prefer transverse incisions because the lateral pull of the oblique and transversalis muscles tends to close rather than open the incision. This is graphically demonstrated in patients not thoroughly relaxed under anesthesia. Furthermore, the transversely cut rectus sheaths with their transverse fibers hold the sutures much more securely, and do not tend to tear out.

FIG. 6.—Closure of peritoneum and posterior rectus sheath of transversalis fascia.



Because of our previous experience with disruptions, some five years ago we adopted a technic for abdominal wound closure which in our hands has practically eliminated, in our clean cases at least, wound disruption and post-operative hernia. In both transverse and vertical incisions, in both upper and lower abdomen, we have employed and are continuing to employ the following technic for closure: Peritoneum and posterior rectus sheath or trans-

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versalis fascia, continuous, fine C silk or No. 00 chromic catgut followed at 2 cm. intervals with interrupted sutures. This is done to bring a continuous

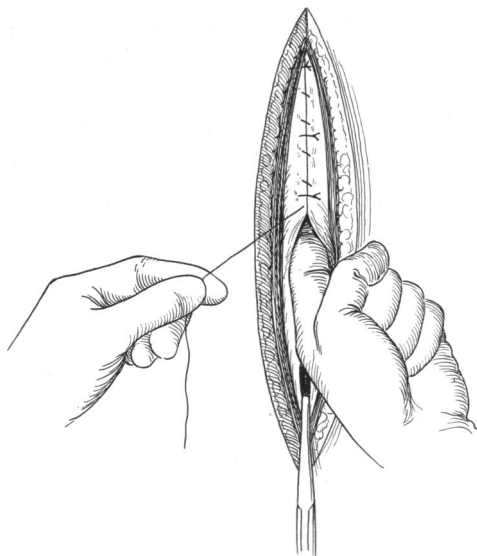


FIG. 7.—Showing the use of continuous fine silk followed by interrupted silk at 2 cm. intervals.

surface of peritoneum to peritoneum, to insure prompt agglutination of peritoneal edges, and to prevent possible projection or protrusion of omental tabs into the peritoneal repair (Figs. 6 and 7). The anterior rectus sheath and oblique muscles (in the transverse incisions) are repaired with the same fine silk or chromic catgut by the use of a vertical figure-of-eight, or what we call the "far-and-near" stitch, at intervals of 7 to 8 Mm. This stitch is begun by introducing the needle 5 Mm. from the edge of one sheath out through the margin of the other edge, into the margin of the first edge and out 5 Mm. from the margin of the opposite sheath. Slight tension on the suture ends approximates the two edges of the sheath. These interrupted sutures should be tied loosely with a square knot, to allow for the take-up that results from the occurrence of the edema of repair, and to prevent any cutting of the sheath by the suture (Fig. 8). This is a tensionless suture, if loosely tied, which prevents tissue necrosis, and therein lies its virtue. Proper hemostasis will obviate any need for subcutaneous sutures. The skin is closed with

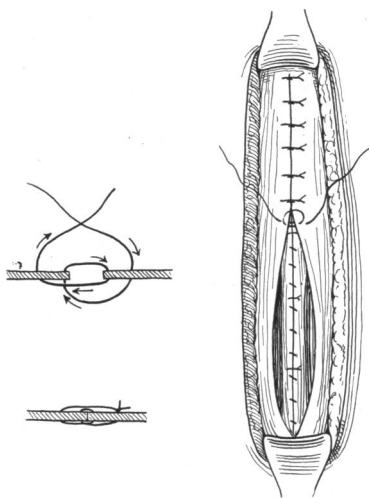


FIG. 8.—Closure of the anterior rectus sheath with "far-and-near" interrupted fine silk sutures.

interrupted silk sutures on separate cambric needles to avoid the contamination of the silk by repeated puncture of hair follicles and sweat glands with the same needle and the same long suture (Fig. 9).

We claim no originality in this technic, although we have not seen this identical procedure described. Babcock⁷ describes this suture as "a combined relaxing and coapting suture, one of the best sutures for use where there is tension." Dr. H. H. Lyle of St. Luke's Hospital informs me that this "far-and-near" suture has been used for many years on his service, employing catgut, and that Thomas Markoe began using it for rapid closure of war wounds during the Civil War. Dr. Daniel F. Jones used a similar stitch for

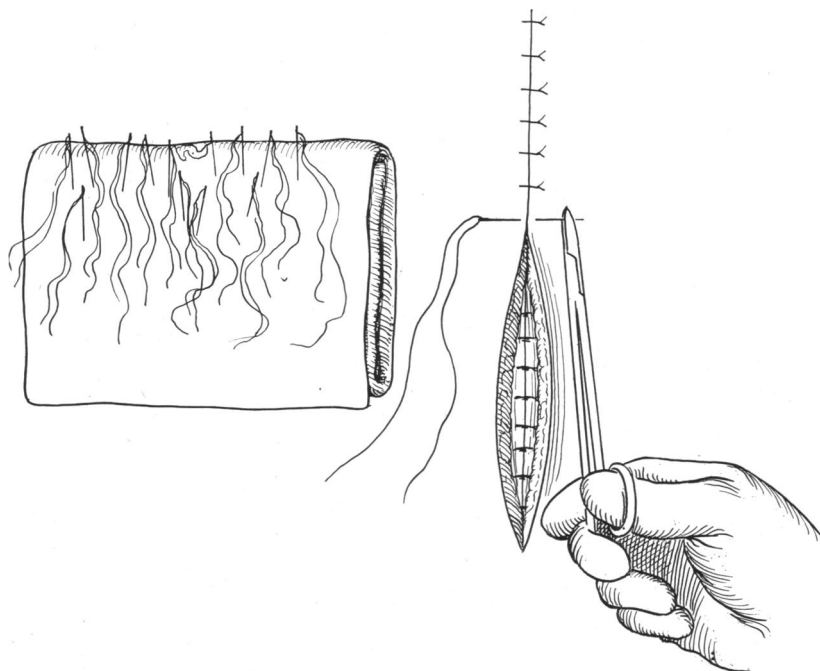


FIG. 9.—Closure of skin and subcutaneous tissue with interrupted fine silk on separate cambric needles.

deep retention sutures. Undoubtedly it has been used by others, as we are using it, but we have failed to find a description of the technic for abdominal wound closure such as we are now employing. We do know it has reduced wound disruption and postoperative incisional hernia to a minimum in our postoperative and follow-up studies. For this reason we have abandoned the use of retention sutures, which seldom proved effective, and frequently caused stitch abscesses.

In a control series of 300 abdominal wounds, with the layers closed with catgut, bolt retention sutures tied over pearl buttons were used in the great majority of cases. We first saw these pearl button retention sutures used in Bevan's Clinic at the Presbyterian Hospital, Chicago. Yet the incidence of

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wound infections, disruptions and postoperative ventral herniae was far greater (Tables I to V). Table VI shows the distribution of cases in the series reported and in the control group. It will be observed that the number of biliary, stomach and bowel cases in the two series are roughly comparable, the numerical difference between the totals of the two groups being due principally to the number of appendicectomies and herniae in the reported series.

TABLE I
THE INCIDENCE OF SUTURE MATERIAL AND THE TYPE OF SUTURE USED IN THE ANTERIOR SHEATH

Material	No. of Cases	F. & N. Suture	Plain Suture
Silk.....	300	228	72
Catgut.....	181	102	79
Control*.....	300	0	300
Totals.....	781	330	451

* Cases in the control group were sutured with catgut.

TABLE II
INFECTION IN CLEAN OPERATIVE WOUNDS

Material	No. of Cases	Triv. Inf.	Per Cent	Ser. Inf.	Per Cent	Total Inf.	Per Cent
Silk.....	199	4	2.04	0	0.0	4	2.04
Catgut.....	25	1	4.00	0	0.0	1	4.00
Totals...	224	5	2.22	0	0.0	5	2.22
Control.....	53	4	7.55	2	3.77	6	11.32

TABLE III
INCIDENCE OF DISRUPTION

Material	F. & N. Suture	Per Cent	Plain Suture	Per Cent	Total	Per Cent
Silk.....	1	0.44	0	0.0	1	0.33
Catgut.....	4	3.92	1	1.26	5	2.76
Totals.....	5	1.51	1	0.66	6*	1.25
Control.....	—	—	13	4.34	13	4.34

* Two cases have not been included in which dehiscence of the wound took place, because the separation of the wounds only extended down to, but not through, the anterior rectus sheath.

In our tables are included the abdominal incisions repaired, with the technic described, both with fine silk and fine chromic catgut, and a series of 300 cases repaired with chromic catgut in the usual manner, that is, with continuous sutures and reinforced with retention sutures. We use the term trivial infection for any case in which the healing of the wound was not delayed.

This includes single stitch infection or wounds with a serous discharge giving a positive culture. Serious infection is one which delays the normal convalescence and prolongs the bedstay of the patient.

TABLE IV
FOLLOW-UP STATISTICS

Material	Cases Followed	Per Cent Followed	Ave. No. Mos. Followed
Silk.....	173	57.7	13
Catgut.....	111	61.4	17
Totals.....	284	59.2	15
Control.....	203	67.7	52

TABLE V
INCIDENCE OF POSTOPERATIVE HERNIA AMONG
CASES FOLLOWED

Material	No. Herniae	Per Cent
Silk.....	0	0.0
Catgut.....	7	6.31
Totals.....	7	2.46
Control.....	30	14.77

TABLE VI
DISTRIBUTION OF CASES

Type of Operation	Silk	Catgut	Total	Control
Hepatic and biliary.....	81	81	162	140
Stomach and duodenum.....	40	25	65	57
Large and small bowel.....	16	48	64	42
Appendicectomies.....	23	21	44	3
Herniae*.....	52	0	52	7
Miscellaneous.....	88	6	94	51
Totals.....	300	181	481	300

* Including ventral herniae.

Regular staff conferences and well organized follow-up clinics, in our best surgical services all over this country, have made the surgeons, especially the younger group, very critical of any statements regarding wound healing and postoperative herniae based upon impressions and not backed up by searching analyses of carefully kept records. Such studies have revealed a much higher incidence of disruption and ventral hernia in surgical services than the estimates based upon impressions.

Before closing I wish to emphasize again that if silk is to be employed in the repair of wounds, it must be used in the very fine grades. This connotes the minimal tissue damage by the use of sharp knife dissection, fine

hemostats, fine needles, complete hemostasis, absence of tight sutures, careful isolation of skin edges, and protection of exposed tissues from drying and air contamination.

The number of recognized surgeons throughout the country who have adopted silk technic within the past five years is remarkable and speaks for their open-mindedness and their interest in ideal wound healing. It is regrettable that Halsted, who did so much to demonstrate the principles of wound healing, did not live to see the present renaissance of his philosophy.

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DISCUSSION.—DR. SAMUEL C. HARVEY (New Haven, Conn.): I am very happy indeed to have the opportunity of discussing Doctor Whipple's excellent paper. I shall not go into technical details but I wish to restate the problem in a more general way.

There are two ways, of course, of determining the certitude with which the healing of a wound may take place. One is by experimental investigation upon animals, and the other is actual surgical practice. Both of these are essential for our knowledge of the healing of wounds.

From the experimental work upon animals, we have learned that the healing of wounds follows a normal process. It is a biologic phenomenon, which corresponds to the laws of growth in all biologic things.

We have also learned that there are certain things which interfere with the normal healing process. The process is, in the first place, one of cleaning up tissues which have been devitalized—a matter of three or four days. The secondary part of the process, and the most important, perhaps, is the restitution of the tensile strength of the wound by the growth of the fibroplastic cells.

Theoretically, such a process should take place to the best advantage when there is the least amount of destruction of the cells, when there is no infection, and when there is no foreign material introduced in the wound. Frankly speaking, we have to compromise, because a wound has to be carefully approximated in order to obtain healing. This means that we have to use sutures.

The use of sutures introduces foreign material into a wound. It is just as much the introduction of foreign material as is the devitalization of the cell, the introduction of infection, or the forming of hematomata and serous

accumulations. Therefore, it must be reduced to the absolute minimum in respect to the type of material and in respect to the quantity necessary to achieve the purpose of obtaining approximation of the wound.

Experimentally, that means the reduction of the suture material in size to a minimum and the use of suture material which has the least irritative effect in the wound. Clinically, the same thing follows from studies of the complications of wound healing.

I would like to point out more emphatically than Doctor Whipple perhaps did that no one is really in a position to evaluate the healing of a wound clinically unless he has very carefully, and at the time, personally studied the healing of his own wounds. The impression which all of us may have, that our wounds heal all, or practically all, without any complications, is, I am convinced, a completely erroneous one. A careful follow-up and careful evaluation will show, I think, that 4 or 5 per cent, as a minimum, do not heal as perfectly clean wounds.

A measure of that, perhaps the most characteristic and vital measure, is the disruption of the wound. Again, if one studies very carefully his cases as they come along, he will find a very definite incidence of disruption. I do not think there is any exception to that.

Perhaps more important, with a follow-up he will find that there is a definite percentage of postoperative herniae, and a postoperative hernia is, I think, almost without exception, a disruption of the wound, in most instances not involving the skin but the underlying structures.

Therefore, it seems to me that Doctor Whipple's experience here is a very pertinent one and very much to the point because he has carefully carried over into the clinic the indications resulting from his experimental work.

By the criteria of a careful follow-up and study of his wounds, and with the actual decrease of the complications of healing obtained by the use of a nonirritative suture material, in fine and restricted quantities, with the necessary delicate technic that is required, he has actually demonstrated a very significant decrease in the complications of wound healing.

I should like to add this one thing, however, for those of you who wish to follow this procedure: you should go back to Halsted's article, in 1913, in which he gave the details absolutely essential for the successful carrying out of this technic.

DR. ALBERT O. SINGLETON (Galveston, Tex.): Doctor Whipple is to be congratulated upon his management of this very troublesome vertical, upper abdominal incision. I do not know of anyone who has succeeded so well with it. There is no controversy that I can see about his technic and the reason for his employing it. We have approached this subject from a little different angle and have tried to use a more anatomic incision, more or less upon the principle of the incision advocated some years ago by Sloan.¹

The chief strain or tension upon the abdominal wall, in the upper abdomen particularly, is in a transverse direction, due to the action of the lateral abdominal muscles. The chief holding material of the abdominal wall is the posterior sheath of the rectus muscle, which is the tendinous continuation of the internal oblique and transversus muscles. If this is cut vertically across its fibers, the difficulty of maintaining it in position is very great, and when an unusual strain such as coughing and vomiting, it probably is impossible to maintain it in position.

On the other hand, if this structure is cut transversely in the direction of its fibers, it may be split across the linea below, and by retracting the rectus muscle out of its sheath on either side, sufficient room may be acquired for

almost all operations upon the stomach or gallbladder, *etc.* When the wound is closed, its edges automatically come together. No tension is required to coapt them, and thus no strangulation of the tissues can occur.

This same principle may be employed in an incision we are using lateral to the the rectus muscle, in which the rectus is retracted medially. This incision is employed on the right side for operations upon the biliary passages, and on the left side for operations upon the splenic flexure of the colon, and particularly for splenectomy. It begins near the midline, three to four inches above the umbilicus, and extends obliquely downwards and outwards, just below the rib margin, almost to the iliac crest, just posterior to the anterior superior spine. This is in the direction of the fibers of the internal oblique muscle. The anterior sheath of the rectus muscle is cut transversely and the muscle freed from the sheath for a short distance above and below. The incision is continued across the fascia of the external oblique for two to three inches in line with the skin incision, and the external oblique is retracted further, laterally. The rectus muscle is retracted toward the midline, and its posterior sheath is split from the linea alba, laterally, into the internal oblique and transversus muscles. The internal oblique is split and the transversus and peritoneum cut in the same incision. This gives a very advantageous exposure of the gallbladder, bile ducts, appendix and pyloric end of the stomach on the right side. The wound comes together without tension and is quickly and easily sutured in layers.

The incision may be used to advantage on the left side in operations for removal of the spleen, and affords a better exposure than the usual incisions and with no danger of disruption or weakening of the abdominal wall.

Our experience, as indicated here by a review of 710 consecutive upper abdominal incisions, is that, of the vertical incisions, 284 had nine disruptions, or 3.2 per cent; 15 herniae occurred, or 5.3 per cent. Of 426 transverse incisions (if I may call these transverse), we had no disruptions, and only one hernia was found, which occurred in a patient who had had an omentopexy performed for cirrhosis of the liver.

The suture material in these cases was not investigated. We know that disruptions occurred in the first series of vertical incisions in which silk was employed in conjunction with plain and chromic catgut. The suture material which has been used in these 426 cases has been either plain No. 1 catgut or No. 0 chromic catgut.

The time required for making the incision is longer but the patient is more comfortable following the operation, and the sense of security in the mind of the surgeon makes the extra effort well worth while.

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DR. HOWARD LILIENTHAL (New York City, N. Y.): Speaking only of perfectly clean wounds, it must be obvious that an infection in a perfectly clean wound is usually carried in by the scalpel.

I do not use a scalpel. I use the diathermic knife, the electrical scalpel. It has to be used with care, speed and precision, and thus obviates infection from the skin, even the deeper layers.

DR. ROSCOE R. GRAHAM (Toronto, Canada): An analysis of our wound infections and wound disruptions has shown a higher incidence than in the series which is being reported by Doctor Whipple. While Doctor Whipple is placing great emphasis on the type of suture material, and making a plea for

the efficacy of silk in wound closures, the actual type of material is probably not as important a factor as he would lead us to believe. One has but to see Doctor Whipple operate, to recognize the gentleness and care with which he treats tissues, and this I think, in no small way, has contributed to the excellence of his results. In our own series we have had no incidence of wound infection in which there was not evidence of an accumulation of serum or imperfect hemostasis in the wound. The former we believe is due to massive ligatures or traumatic methods in opening the abdominal wall. In other words, meticulous, sharp dissection, having regard for anatomic structures and planes, the avoidance of mass ligatures, and the securing of perfect hemostasis are probably the important factors in securing firm, primary healing of abdominal wounds. These above requirements must of necessity be fulfilled if the surgeon employs silk, and in this regard, the use of silk making necessary such a type of technic constitutes its greatest virtue.

DR. WALTER D. WISE (Baltimore, Md.): I would like to call your attention to a subject that I hesitate to bring before this Association, except to pass it through this organization to many of the younger surgeons. It is about the matter of knots.

One constantly sees, if one is alert to that subject as some of us have been taught to be by avocations instead of vocations, particularly that of sailing, the indifference with which surgeons tie knots. Speed, it seems, is what they are endeavoring to accomplish rather than meticulous care in tying a flat or reef knot.

This does not apply, of course, so much to silk as it does to catgut. In the use of silk, a granny knot will hold quite well, but it is not entirely reliable. In the use of catgut, anyone who has watched it swell and untie itself will realize that it is essential, not only to tie a reef knot, but to use a third throw.

What I am saying does not apply only to closing incisions, but it applies more particularly to the ligation of vessels, and probably accounts for some of the catastrophes.

It is probable that a good many disruptions of wounds, as has been hinted at but not actually said this morning, occur in the first day, or probably during the first hour or two after an operation, resulting from the act of vomiting or straining. That is the time, regardless of when the catgut digests or if there is any allergy or any other factors involved, when one wants the knot to hold. If the knots are tied with the indifference that one sometimes sees, then this may account for some instances of disruption.

DR. JOHN J. MORTON (Rochester, N. Y.): I would like to endorse Doctor Whipple's discussion on the healing of wounds because I have been using practically an identical technic during the last five years. I think that it should be emphasized that he does not make use of so-called retention sutures. I have given up using retention sutures also. The use of very fine silk, C grade, provides for accurate approximation of the divided tissues. There is one difference, however, in our technic. When we make a vertical incision, we go to the edge of the rectus muscle and retract the rectus over, so that we have our incision staggered and bolstered by the rectus muscle in front. I think this may help in some cases when postoperative distention occurs.

I have been very much pleased with this type of closure and I use it in gastric and gallbladder surgery as a routine. It is used on a good many other lower abdominal cases and even in some large bowel resections, when I am reasonably sure that there has been no major contamination.

DR. HARVEY B. STONE (Baltimore, Md.): There is one factor which has been mentioned only passingly, and which I think needs at least a word of

reference: that is, those cases of wound disruption which occur, apparently due to a failure of the healing power of the tissues, and which I believe in some instances have no relation either to the type of incision made or the material employed in the suture, or any of the other defects which have been mentioned previously.

I am confident that there are wounds which for some unknown biologic reason do not heal and I think in those cases, no mere technical procedure is going to correct that failure.

In the past, it has seemed to me that the incidence of such wounds has been strikingly high in patients suffering with advanced malignant disease, and in old age, conditions in which the recuperative power of the tissues is naturally lowered. These disruptions often take place in wounds 10 to 12 days after operation, when everything seems to have been progressing normally. The wound suddenly splits open during an attack of coughing or sneezing; when one examines the wound edges, they appear as though made only a day or two before, without any evidence of effective granulation.

Since the routine employment of blood transfusion in operations for malignant disease, it seems to me that the incidence of such disruptions has been remarkably decreased. One might infer that there was a factor that might be detectable in such cases, such as a diminished blood protein as suggested by Doctor Whipple, or some other dyscrasia, that accounts for this failure to heal. Only yesterday, I saw a patient who had had a small fibroma of the skin removed two weeks previously from the thigh; a small wound, two or three inches long, closed with silk. It had apparently healed and the dressings had all been removed. On the thirteenth day, the patient, while driving an automobile, simply cracked the wound wide open, throughout its entire extent. It didn't bleed much, and the cut surfaces looked almost as fresh as though it had been made just the day before.

DR. HUGH H. TROUT (Roanoke, Va.): There are a great many objections to the use of catgut, one of which has not received the attention it deserves. For example, for years we have been thinking that the degree and rate of absorbability of catgut were dependent largely upon chromic or tannic acid. The factor to which I refer is the age of the animal from which the gut is removed.

Our attention was first called to this by the report of Bulloch on Suture Material, made to the Royal Society of Surgeons of England. Since this time we have been doing considerable experimental work, trying to obtain a substitute for catgut, as well as test the absorbability of the various brands and sizes of catgut. Naturally, we have found that the older the animal the less absorbability the gut has. In fact, if one takes an old ram, the gut removed is practically a foreign body. Apparently it is impossible for the manufacturers to know definitely the age of the animals from which the gut is removed.

DR. CHARLES C. LUND (Boston, Mass.): Doctor Stone's remarks have stimulated me to enter this discussion. The work that I am going to mention is so incomplete that I was not planning to say anything about it at this meeting.

As many of you know, Wolbach and others, in 1926, demonstrated that wounds in animals with scurvy will not heal. Recently, determinations of blood vitamin C, the active principle in orange juice, have become reasonably easy to make and are reasonably accurate. At Doctor Cutler's Clinic and in London, it has been shown that the great majority of patients that were being

treated for gastric ulcer have a very low blood vitamin C. Some of them practically have scurvy.

At the Boston City Hospital, on our service we have now made something over 1,000 determinations on several hundred patients with miscellaneous surgical conditions. We cannot report any results as yet, except to say that in the population there are a great number of people of all classes who are running suboptimum levels of vitamin C, many of the levels apparently close to scurvy. Of course the level of serum protein, as mentioned by Doctor Stone, is also important in wound healing.

I think that vitamin C is probably also very important. I will say, however, that the first disruption that occurred in a patient who had a blood vitamin C determination made had an absolutely normal level. We checked up with the house officers and we found that, according to the requirements set forth by Doctor Whipple, this wound had been very, very badly sutured.

DR. PHILEMON E. TRUESDALE (Fall River, Mass.): Doctor Wise has called our attention to the undesirability of knots in wounds. There is a distinct disadvantage in leaving a field of operation studded with knots, especially when the material is chromicized catgut. The knot acts as a foreign body. After taking cultures from the wound before secondary closure, it will invariably be found that the wound is infected, if at all, around the knot. Bacteria may be found in the region of the knot and nowhere else.

There is always some degree of round cell infiltration at the point of fastening. The coarser the ligature, the greater the reaction. On the contrary, a knot which has been tied with fine silk or plain catgut produces very little reaction. A knot tied with No. 1 or No. 0 chromic catgut causes only a mild reaction, with a few bacteria, but when a No. 3 or No. 4 chromic catgut is used, there follows a marked reaction around the ligature. That is why at either end of the wound one frequently feels a hard, tender swelling, due to inflammatory reaction around the ligature.

DR. ALLEN O. WHIPPLE (closing): Regarding the results that Doctor Singleton has obtained by the incision that he uses: We have employed this incision in a number of upper abdominal cases and for gastric work, particularly around the pylorus, and we have found it an exceedingly good one.

In regard to the use of the electric cutting current: We have employed this at times, but it always seemed to me that there was more of a margin of tissue necrosis, even though the current is used quickly, as Doctor Lilienthal has suggested. We still prefer the scalpel incision.

Relative to knots, I am sure that all that has been said is correct about the tying of knots. Certainly in fine suture material, whether it be silk or catgut, a knot can be tied more securely and with less foreign body reaction than when the heavier grades are employed.

I did speak about the low serum protein in the cachectic individual with very poor wound healing. I am sorry that I did not bring that observation out more fully. Many of the points, because of the time, I was not able to deal with as fully as I would have liked to.

Doctor Harvey and Doctor Morton have really touched upon the important feature of wound healing, and that is: That in order to get optimum wound healing, whether one uses silk or catgut, one must minimize the tissue damage, and if one uses silk, the philosophy that goes with it develops inevitably and tends to minimize constantly tissue damage.