

SOME REMARKS ON THE METHOD OF INCISION OF THE ABDOMINAL WALL IN THE PERFORMANCE OF LAPAROTOMY.

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It is a matter for surprise that in the literature of the country that claims Grieg Smith for her own so little is found bearing on this subject. Most of the principles that underlie it may be gleaned from his pages, although he himself did not take full advantage of them when suggesting a substitute for the venerable "incision through the linea alba." Of late years attempts at improvement have all been in the direction of varying the method of closing the wound, its site, for various reasons of convenience and of simplicity of arrangement combined with inconsiderable vascularity of the tissues divided, remaining the same. Yet this site, the linea alba, must be regarded as one of the weakest of the defences surrounding the abdominal viscera, for, as the result of physiological intra-abdominal tension—not necessarily frequently repeated—the normal linea alba is found expanded and thinned in a large number of parous women. This hint has been recognised only to be disregarded, and the weak spot has continued to be the site of election.

When mass sutures were used to close the median incision they grasped the entire thickness of the abdominal wall and indiscriminately united its tissues without any regard to their anatomical characters. The result was a wedge of cicatricial tissue mortised into the abdominal wall like a tenon into a piece of wood—a cicatrix extending from skin to peritoneum and firmly adherent to all the component structures of the parietes. This wedge had to bear, in common with the normal constituents of the wall, its share of the tension caused by physiological movement, and of the strain and stress occasioned by exertion. No doubt at first the scar appeared dense and tough, but, to quote Grieg Smith, its tissue "is comparatively soft and ductile." No doubt in many cases it was capable of resisting for years intra-abdominal pressure and muscular traction, but "stretching of the uniting scar will certainly take place in the end."

Recognition of the unsatisfactory behaviour of cicatrices resulting from the use of mass sutures led to the introduction of the many methods of closing the median incision:—

1. Suturing the edges of each component layer directly to one another. Peritoneum, fasciæ, muscle and skin—each has been united by its own special sutures, or after sewing up the peritoneum, muscles and fasciæ have been united by common sutures. To the onlooker the result appears good, since the sutures as they are placed appear to gradually restore the parts to their normal condition. But it is almost impossible to obtain exact apposition of the cut fascial edges, because they are too thin and pliable to permit of accurate suturing together, and therefore inversion frequently occurs, and obtrusive tags of fat often become caught between the edges as the sutures are being tightened. Moreover, attempts to procure exact apposition would make too great a demand on the time that is often so valuable at the close of an abdominal operation, when the surgeon's chief desire is to sew up the wound as quickly as possible and send the patient back to bed. More important still is the condition of the cicatrix resulting from this method. It differs in no respect from the cicatricial wedge left after the use of mass sutures, and possesses all the objectionable characteristics of the latter. It is a more or less solid block of tissue set in the midst of the parietes, with intimate connections to skin, subcutaneous fatty tissues and deep fasciæ, interfering with the mobility of each layer, and uninterrupted in any part of its extent by intact muscle, whilst, finally, it has destroyed the natural condition of this part of the abdominal wall.

2. Jonnesco, after incising skin and subcutaneous tissues in the median line, excises the linea alba. At the close of the operation he sews, by means of inclusive sutures, the recti and their sheaths directly together. The recti are normally freely movable in their sheaths, and it is doubtful whether partial union in the lower portions of their extent can be more than temporary, since contraction will tend first to thin and then to produce cleavage of the connecting tissue. Weakened fascia only would then be left to withstand intra-abdominal pressure.

3. Juvara closes the median incision by placing the inner edge of one rectus in front of the corresponding one of its fellow, and sewing them in that position, just as a double-breasted coat is fastened.

Other operators have varied the site of the incision, some adopting an extra-median position, whilst others place their incisions transversely.

Extra-median Incisions. 1. That along the linea semilunaris.

Such an incision divides some of the terminal branches of the intercostal nerves that supply the rectus muscle, the corresponding portion of which becomes paralysed and undergoes atrophy. Mickulicz has reported such a case, and a similar one in Czerny's practice led the latter to carry out experiments on animals. The results of these showed conclusively that incision along the *linea semilunaris* was followed by paralysis and atrophy of the rectus, a condition which contributed subsequently to the development of hernia.

2. Other operators have made extra-median incisions at varying distances from the middle line, over, and parallel to the vertical axis of the rectus. The latter is then divided (Segond), or its fibres are separated (Howitz, Abel). Division or separation of the muscle for any distance will certainly interfere with its nerve supply, and may provoke troublesome bleeding from branches of the deep epigastric artery.

Transverse Incisions. 1. Of *transverse incisions* the most important is that associated with the name of Pfannenstiel. Skin and anterior sheaths of both recti are divided transversely 6cm. above the pubes; the anterior sheaths are then dissected up from their attachments to the *linea alba*, above and below the line of incision, the *pyramidales* remaining, as a rule, on the lower segment. The fascial edges now enclose a diamond-shaped space, the long axis of which is formed by the *linea alba*. The latter is divided vertically, and the abdomen opened in the same line. In closing this wound peritoneum and recti are each sewn up with layers of continuous catgut sutures, whilst fascia and skin are included in figure of eight silk-worm gut sutures. The fascial wound is thus protected by intact muscle, except at the point where it crosses the separation between the recti. More will be said later regarding this incision.

2. The extensive incisions practised by Amann and Mackenrodt, with suture of the edge of the upper segment of anterior parietal peritoneum to the *linea innominata*, so as to shut off the upper portion of the peritoneal cavity and its contained viscera from the lower pelvic space. To the onlooker this extensive wound appears unnecessary, and the subsequent occurrence of hernia almost a certainty, since the cicatrix must possess in a marked degree all the disadvantages associated with that following the vertical median incision.

Characterised by thoughtful ingenuity as these procedures are, yet it is plain that only one of them (Pfannenstiel's) can be followed by the production of an efficient cicatrix. The requirements obviously necessary in such a cicatrix are:—

1. Its continuity must be interrupted by the interposition of intact muscular fibre which shall give support to and protect fascia weakened by incision.

2. The cicatrix must not interfere with the original freedom of movement possessed by each separate layer of the parietes.

Such conditions can only be obtained by devoting more attention to the method of opening the abdomen than has been the case in the past. The parietal incision should be easy of performance, capable of being readily closed, and so planned that when closed it shall leave the parietes as far as possible in their original condition. In order to meet these conditions it must be founded upon an anatomical basis, and it is therefore advisable to bear in mind a few of the more important details of the anatomy of the abdominal wall.

The anterior abdominal wall is formed of a musculo-aponeurotic sheet enclosed between skin externally and peritoneum internally, and separated from these investing structures by connective tissue layers of varying thickness.

1. *Skin.* The investigations of Karl Langer showed that the skin fibres of the anterior abdominal wall pursue a course mainly transverse in direction. They sweep round from the dorsum, with a slightly downward tendency, towards the linea alba. In the epigastric region the transverse direction is very marked; in the lower half of the abdomen scattered oblique fibres become interspersed with those running transversely; in the umbilical region the fibres are arranged in a series of concentric rings, towards which median vertical bands run from the thorax above and the pubes below. When these fibres are divided at right angles to their course, their retraction leads to gaping of the wound, as Kocher has shown, whereas an incision placed parallel to their course gapes to a less extent, or not at all. The cutaneous cicatrix resulting from an incision placed at right angles tends to broaden, as is seen in the scar following the median incision. On the other hand, it is claimed that a transverse skin incision does not tend to broaden (Pfannenstiel), because when the fibres are cut in a direction parallel to their course their natural state of tension approximates the edges of the wound. As a matter of fact, a transverse skin incision of any length made above the symphysis pubis *does* gape, and its cicatrix does broaden, but both of these take place to a much less extent than in the case of the vertical incision. The gaping of the wound is all the more marked when there is an abundance of subcutaneous fat. The broadening of the cicatrices is due primarily to expansion of

the abdominal wall produced by physiological and voluntary movements.

2. The musculo-aponeurotic layer is formed on each side of the middle line by:—(i.) Three large flat muscles which become tendinous as they sweep forwards and inwards. The tendon of the middle muscular sheet—the internal oblique—divides into two layers, the anterior of which unites with the tendon of the external oblique to form the anterior wall of the sheath (called hereafter the “anterior sheath”) of the rectus abdominis, whilst the posterior combines with the tendon of the transversalis muscle. The upper two-thirds (Quain) of this combined tendon pass behind the rectus to form the greater area of the posterior wall of its sheath (called hereafter, together with the structures forming the lower third, the “posterior sheath”), whilst the lower third passes in front of the rectus to become blended with the anterior sheath. (ii.) The rectus and pyramidalis muscles occupy the sheath thus formed on each side by the tendons of the flat muscles. The recti lie with their convexities close to one another from pubes to umbilicus. From the latter point upwards to the xiphoid process they diverge, their median edges being 2—3cm. distant from each other at the umbilical level, and 1—2cm. above this point. This space is filled by an aponeurosis 2—3mm. in thickness (Rotter). (iii.) The linea alba is formed by decussating fibres which unite the sheaths of the recti in the median line. It measures 2—3mm. in thickness, and, below the umbilicus is a line normally, being as a matter of fact a thickened cord denoting the direct union of the sheaths. At the umbilicus it expands into a flat circular space 15—25mm. in diameter, in the centre of which is the umbilical cicatrix. Above this circular space the width diminishes, but remains greater than below it. Repeated over-distension, as by pregnancy, leads to broadening of the linea alba at the expense of its thickness. The line is, therefore, one of the weak parts of the abdominal wall.

The sheath of the rectus formed in the manner outlined above possesses anterior and posterior walls, and internal and external borders. The anterior wall consists usually of two stout fibrous lamellæ, reinforced in their lower third by the combined tendon of the transversalis and the posterior layer of the split internal oblique tendon. The posterior wall is much thinner, except at its outer part above the navel, where the muscular fibres of the transversalis are prolonged into it for a varying distance. About 3cm. below the umbilicus there occurs a marked thinning due to the departure anteriorly of the majority of the fibres of the com-

bined transversalis and internal oblique tendons. A lunated edge with its concavity directed inferiorly is thus formed—the semi-lunar fold of Douglas. Below this occur one or two thinner and less defined arches, the sheath being completed between and below these by the transversalis fascia and the umbilico-pelvic fascia (Paul Petit), the latter passing down to join the vesical division of the pelvic fascia. This portion of the wall is thin and delicate, incapable of offering resistance, and its integrity depends on the support afforded by the rectus muscle. The internal border is formed by the angle of union of the anterior and posterior walls. Below the umbilicus the internal borders practically correspond to the linea alba. The external border is formed above by the bifurcation of the tendon of the internal oblique into its two lamellæ, but in the lower third (Quain)—the lower fifth according to Testut—by the angle between the fascia transversalis and the tendon of the transversalis muscle. Immediately external to this border is the curved linear depression termed the linea semilunaris. It shows itself as a white line, and “corresponds to a narrow portion of the aponeurosis of the internal oblique, between its division to form the sheath of the rectus internally, and the termination of the fleshy fibres of the muscle externally.” (Quain.)

This fibrous sheath is perfect, except for small openings which give passage to vessels and nerves, of which the most important are:—Above, that by which the abdominal branch of the internal mammary artery enters; below, on the lateral aspect, the openings admitting the deep epigastric artery and giving exit to its supra-pubic branch; posteriorly, numerous small openings for the terminations of the intercostal nerves; and, anteriorly, for their cutaneous branches and also for a vessel which passes through the sheath about three inches below the umbilicus. These vessels and nerves have this in common, that after perforating the sheath they are continued for a short distance between it and the muscle before entering the latter. The abdominal branch of the internal mammary lies so high that it is not likely to be met with. The deep epigastric, after passing through the transversalis fascia, crosses the fold of Douglas and then enters the rectus. When the posterior sheath is separated by the fingers from the muscle the artery remains attached to the latter, and does not obtrude itself in any way unless there has been any pre-existing inflammatory condition, although its pulsations may be felt if searched for.

The terminations of the intercostal nerves course between the internal oblique and its tendon anteriorly and the transversalis

posteriorly, as far as the outer edge of the rectus, where finally perforating the posterior layer of the sheath they are continued between it and the rectus for a short distance before turning forward to penetrate the muscle. In this part of their extent they occur at intervals of about two inches. Vertical incisions or blunt separation of the muscular fibres for any distance will divide at least one such nerve.

A layer of cellular tissue lines the sheath, attaching the muscle to it, but readily permitting separation by the finger, especially on the posterior aspect where the loose tissue sweeps uninterruptedly from pubes to thorax. Anteriorly, its continuity is broken by the *inscriptiones tendineæ*. There are usually three of these, one being placed opposite the umbilicus, another about the level of the lower end of the xiphoid process, and a third intermediate between them. When others are present, one usually occurs below the navel (Quain); this has occurred three times in my experience of forty-eight cases. According to Holden those on the right are a trifle larger than those on the left. These fibrous intersections involve only the superficial fibres of the rectus, and do not usually extend so far as its edges. A few light strokes of the knife are sufficient to divide the attachment.

Study of the foregoing points leads one to the conclusion that the rectus muscle and its sheath must be utilised in order to obtain the requirements stated above as being necessary to constitute an efficient cicatrix. The fascial layers divided must be the anterior and posterior sheaths, the resulting cicatrices in which can be supported and protected by the intact rectus. The procedure necessary to obtain this is performed as follows:—

1. The incision is made about one inch from the middle line, over either right or left rectus. As the surgeon usually stands on the right-hand side of the patient, it is more convenient to select the left rectus. Occasionally, the right half of the abdomen may be incised if more direct access to the disease—for instance, right salpingo-oöphoritis—is thus given, but practically the point is of little importance. The sheath of the rectus must be cleanly exposed, and a vessel which pierces the sheath three inches below the umbilicus should be picked up and ligatured before division. It is necessary to ligature all bleeding points, as mere forcipressure is insufficient (Fig. 1).

2. The sheath of the rectus is opened with the scalpel about three-quarters or one inch from the *linea alba*, and the opening enlarged vertically upwards and downwards for the required distance. The inner half of the divided sheath is picked up with dissecting forceps,



FIG. 1.—The incision has been made through skin and subcutaneous tissues, and the rectus sheath (of left side) opened.

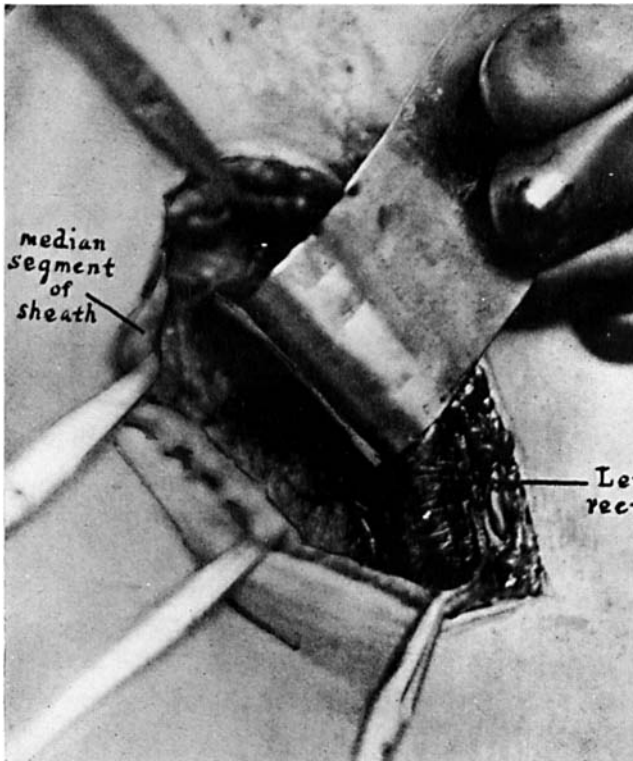


FIG. 2.—The left rectus sheath has been opened; the muscle has been drawn externally by a retractor, exposing the posterior sheath. The median segment of the anterior sheath has been picked up by means of

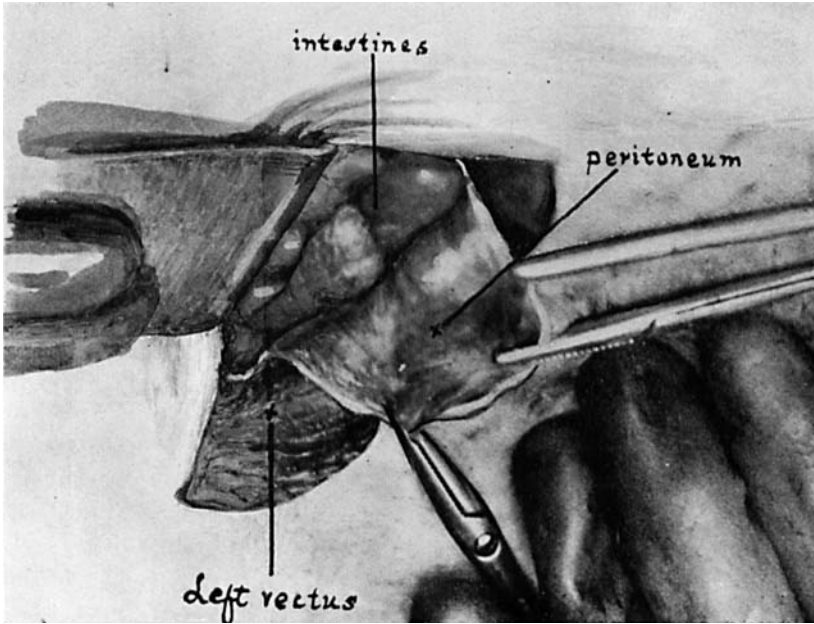


FIG. 3.—The posterior sheath and peritoneum opened.

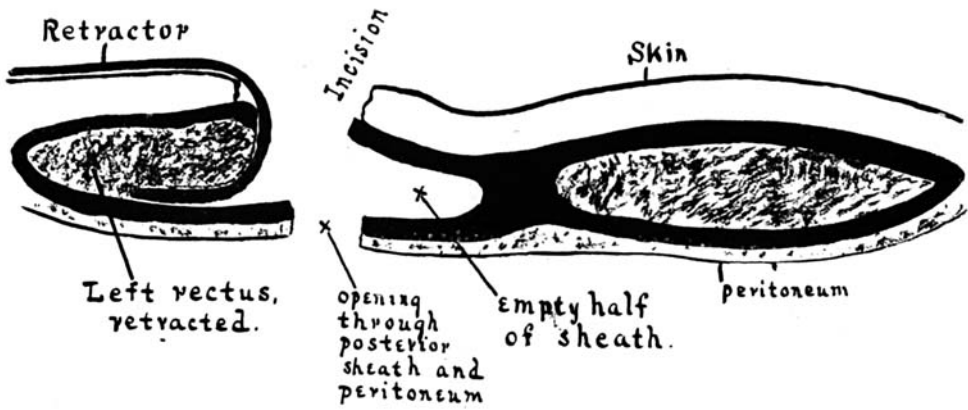


FIG. 4.—Diagrammatic representation of the path followed by the incision.

and separated by means of the handle of the scalpel from the underlying muscle. This is usually easily effected as far as the inner border where the tendinous attachment may require a touch of the knife to complete separation. By keeping close to the sheath one avoids the risk of burrowing between the muscular bundles and setting up troublesome bleeding. Occasionally the pyramidal muscle is well developed and may have a strong tendon of insertion. Once the handle of the scalpel has passed beyond the edge of the rectus it can be gently moved up and down until the opening is sufficient to admit two fingers, by which separation is easily completed, and a sweep of one finger underneath the muscle breaks down the areolar tissue attaching it to its sheath. The rectus is now drawn externally by means of a retractor, the posterior sheath being thus exposed. At this stage the head of the table is lowered so as to place the patient in the Trendelenburg position (Fig. 2).

3. *Opening the peritoneal cavity.* The posterior sheath and underlying peritoneum are picked up between two pairs of Spencer Wells' forceps an inch from the median line, and the ridge intervening between them is incised in the usual manner. As a rule this layer is very thin, the extra-peritoneal fat being abundant only in obese persons, and the median column of fat behind the linea alba is completely avoided. No vessels require tying. The peritoneal edges are now clamped carefully to those of the skin all the way round the wound—the retractor being withdrawn—and the operation is proceeded with (Fig. 3).

Enlarging the wound. This is rarely necessary, as the rectus muscle, freed extensively from its sheath, can easily be drawn aside by means of a retractor. When prolongation of the incision is required each layer must be separately divided. If the prolongation be in an upward direction, one or two of the inscriptions tendineæ may be encountered and can be readily severed with the scalpel. In order to preserve the relations of the skin and fascial incisions to the inner border of the rectus muscle both the former should be inclined outwards as the umbilicus is approached. In the same manner when the opening through the posterior sheath and peritoneum is being enlarged in the downward direction, the cut must slope outwards, and the bladder should be carefully guarded with the finger. To put the matter in a nutshell, long incisions should be slightly crescentic in form with the convexity directed inwards (Fig. 4).

Method of closure. All gauze "dabs" having been removed from the peritoneal cavity, the intestines and omentum are re-arranged as far as possible, and a fresh "dab" placed to shut them

off from the open wound. The latter is now sutured, the method differing slightly according whether drainage is adopted or not.

A. *Without drainage of the abdomen.*

1. The forceps clamping skin and fascial edges together are removed and the assistant keeps the rectus out of the way whilst the extremities of the incision through the posterior sheath are picked up with forceps and as far as possible drawn externally. The opening in the posterior sheath is then rapidly closed with a continuous silk suture, beginning at the umbilical and finishing at the pubic end, the "dab" being withdrawn before complete closure. When the opening has been so reduced that it will admit only a finger, my custom is to introduce the end of a short drainage tube and keep it in position whilst the patient is being raised from the Trendelenburg to the horizontal position. In this way all air escapes, the tube is withdrawn and closure completed. In some cases the posterior sheath cannot be drawn externally, and it is then necessary to use a handled needle.

2. The median edge of the rectus is drawn to the middle line and re-attached to the inner border of the sheath by one or two sutures to maintain it in position. As a rule one is enough.

3. The anterior sheath is now closed with a continuous suture of fine silk.

4. The skin edges are brought together with a continuous subcuticular, iodised catgut suture. This leads to the formation of a finely linear cicatrix, does away with suture scars, and has the additional advantage that there are no sutures to be removed subsequently (Fig. 5).

Dressings. A loose roll of gauze is placed parallel with each edge of the wound, and both rolls are pressed together while two absorbent pads are applied over them. The binder is firmly pinned on, and then a flat sand-bag is placed over all and kept in position for twelve hours. The weight of the bag varies from six to nine pounds, according to the amount of fat in the abdominal wall—the greater the thickness of the fatty layers the heavier the bag. When first employing this incision I was not careful to *ligature* all bleeding points. Experience showed that the forcipressure sufficient to stop bleeding from vessels opened by the median incision was not enough, and that oozing subsequent to the closure of the wound led to the formation of subcutaneous hæmatomata, and in one case to the formation of a blood collection within the rectus sheath. Even after all bleeding points have been secured there is a tendency to oozing, but since the use of the sand-bag was initiated there has been

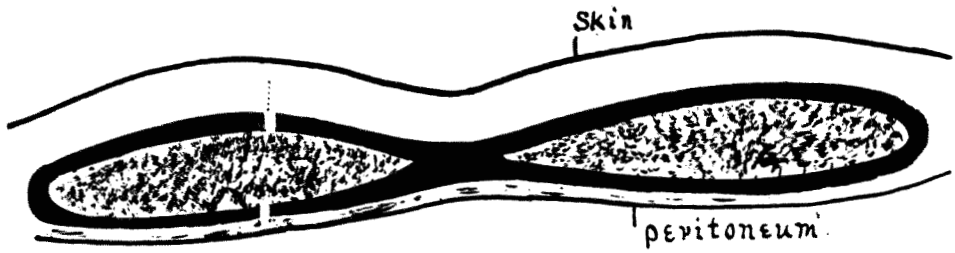


FIG. 5.—Diagram illustrating the relations of the parts after closure of the wound. The track of the incision is shown by black and white lines.

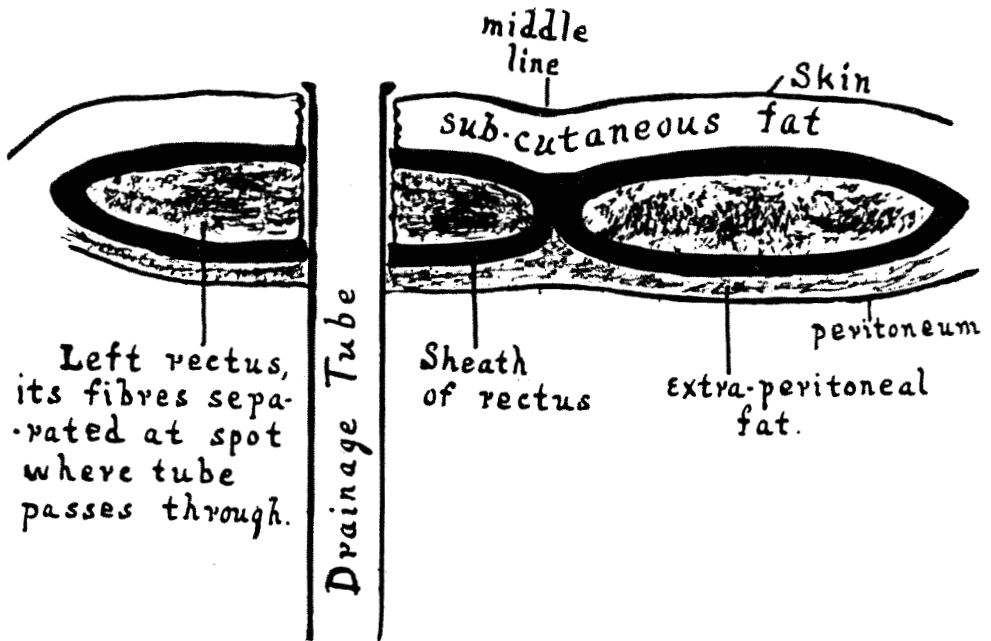


FIG. 6.—Diagram illustrating the use of a glass drainage tube.

no trouble from this cause. When the dressings are removed on the eighth day the wound is found healed, and is afterwards kept covered only with a piece of gauze secured in place by strapping.

B. With drainage of the abdomen.

1. The glass drainage tube is placed in the lower angle of the incision through the posterior sheath and peritoneum, and the latter opening is sewn up as previously described until the tube is loosely grasped by the unsewn edges.

2. The rectus muscle is then replaced, and by touch the operator ascertains the exact part of the muscle that overlies the rim of the drainage tube. With blunt forceps he then separates the muscular fibres of this part to an extent sufficient to allow the tube and its attached thread to be drawn through. The inner edge of the rectus is attached to the inner border of the sheath, the opening in the anterior sheath sewn up till the tube is loosely grasped, and the skin wound closed, as above described (Fig. 6).

Dressings. A roll of gauze twisted into the form of a collar must encircle the mouth of the tube to prevent the latter being driven against the structures at the bottom of the pelvis by the weight of the sand-bag.

When drainage has been necessary I have usually employed a gauze drain passing externally per vaginam, and have only used the glass drainage tube in a few cases. It is not therefore possible to give any indication of the effects of its use on the rectus and its sheath, *i.e.*, whether the muscle remains adherent to the sheath at the point where the tube passed through them or regains its mobility. So far as my observation goes the rectus appeared to contract freely and without dragging on the cicatrix.

Although this procedure was independently devised two years ago, no claim for priority is made, investigation of the literature having shown that the credit of inventing the method belongs to Lenander (of Upsala), who practised it in 1893. In his earlier cases he loosened and displaced the *outer* edge of the rectus *inwards*. Consequently several nerves were exposed in the field of operation, and as a result the opening into the peritoneal cavity was limited. Lenander in subsequent cases therefore displaced the median edge of the rectus outwards after incising the anterior sheath from $\frac{1}{2}$ cm. to 2cm. from the middle line, and last year I believe (although I am unable to find the reference) an English surgeon described the same method, whilst this year Monprofit detailed it in France.

I have carried it out in 48 cases, in eight of which the right, and in 40 the left, rectus sheath was opened. The operations were performed for the pathological conditions usually found in the female pelvis, fibroids and carcinoma of the uterus, ovarian cystic adenomata, ectopic gestation, inflammatory diseases of the appendages, etc. In the earlier cases post-operative trouble arose by reason of subcutaneous oozing from vessels that ought to have been ligatured, and in some of these suppuration occurred, but the sheath of the rectus was only once involved. The method should be reserved for cases that are "clean" at the outset, although it has been employed in pyosalpinx without the occurrence of suppuration. Pfannenstiel has reported similar experiences with his method of incision, and he states that the prevention of parietal infection is merely a matter of protecting the parietal wound from contact with pus. To afford such protection is no easy matter, and there can be no doubt that the risk of infecting extensive connective tissue planes is too great to justify the employment of this incision in cases known to be infective before the opening of the abdomen.

In all other cases its advantages are manifest. It is easily carried out, easily closed, and after closure the thick rectus muscle supports the wound in the posterior sheath, and protects that in the anterior from intra-abdominal pressure, whilst the linea alba remains intact. How advantageous is the method is realised when a patient begins to strain before the dressings have been applied. The contracting rectus can be felt as a firm band effectually shielding the anterior fascial and the skin wounds from intra-abdominal pressure. In one case there has been an opportunity of investigating the rectus and its sheath two months after the incision had been employed. In May of the present year bilateral ovarian cystic adenomata were removed, and on microscopic examination they proved to be malignant. The patient was re-admitted to hospital in July with a hard irregular swelling in the pelvis. The right sheath of the rectus had been opened at the first laparotomy, and the second incision followed as far as possible directly in the path of the first. There was very little scar tissue in the subcutaneous fat, the anterior sheath was thickened, the rectus itself might never have been interfered with, and was as easily separated from its sheath as if the latter had never been opened. There was no trace of a cicatrix in the posterior sheath, nor were there any adhesions on its peritoneal aspect. In short, the abdominal wall was in the normal condition. So far as it goes this is satisfactory, but the success or failure of the method can only be shown after the lapse of years. Up to the present time there

has been no failure, even in the cases in which suppuration occurred, and *although none of the patients have ever worn abdominal belts.*

I think the procedure is a distinct advance on the median incision, however the latter be closed, and as such is worthy of a more extended trial.

The incision devised by Pfannenstiel is an excellent one, but it carries the disadvantage that the linea alba is wounded by its performance. I have, therefore, ventured to modify the method slightly in the eleven cases in which it has been carried out. The skin incision is made about one inch and a half above the upper border of the pubes, and is slightly curved so as to lie accurately in the transverse crescentic furrow, marking the upper limit of the pubic hair. The anterior sheaths are divided transversely, and severed from their attachments to the linea alba above and below. In doing this the knife must be kept close to the sheaths, so as to leave the linea standing up like a ridge between the recti. One or other muscle is now separated from this ridge, drawn externally, and the exposed posterior sheath opened in the manner previously described. In closing the wound the displaced rectus should be restored to its proper position and secured to the linea alba by a single suture. The anterior sheaths are now replaced and reattached to the linea alba by a few sutures before uniting the edges of the transverse cut. The skin wound is closed by the subcuticular continuous suture, and dressings applied as before. It is advisable to use a sandbag over the dressings for twelve hours. The space afforded is not very large, but it is sufficient to permit of the removal of ovarian cysts, of moderate, non-suppurative disease of the appendages, and of small fibroids, whilst the incision is an ideal one for the performance of ventro-fixation of the uterus.

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