

## LITERATURE.

- Lindner. Berl. klin. Woch., 1898.  
 Bouglé. Bull. et mém. Soc. Anat. de Paris, 1900, S. 6, v. II.  
 Gérard Marchaut. Bull. et mém. Soc. de Chir., 1898.  
 Richard. Bull. et mém. Soc. de Chir., 1899.  
 Jaboulay et Brian. Lyon Medical Journal, 1896, lxxxI.  
 Fossataro. Annali di Medicina Navale Roma, March, 1901.  
 Peugniez. Gaz. méd. de Picardie, 1900, xviii.  
 Murphy. Medical Record, Jan. 16, 1897.  
 Kümmell. Beitr. z. klin. Chir., 1900.  
 Dörfler. Beitr. z. klin. Chir., xxv, H. 3.  
 Jacobsthal. Beitr. z. klin. Chir., xxvii.  
 Payr. Arch. f. klin. Chir., 1900, H. 1.  
 Heidenhain. Centrbl. f. Chir., 1895, No. 49.  
 Abbé. New York Medical Journal, Jan. 13, 1894.  
 Jassinowsky. Arch. f. klin. Chir., 1891, p. 42.  
 Seggel. Munch. med. Woch., Aug. 2, 1900.

A CONTRIBUTION TO THE STUDY OF CAT-GUT AS A SUTURE AND LIGATURE MATERIAL.<sup>1</sup>

BY HUGH CABOT, M.D., BOSTON.

THE extent to which absorbable suture materials have come into general use makes it of the first importance that we should have quite definite ideas in regard to the position which they hold as compared with the unabsorbable materials. The question of sterilization has called forth much able and thorough investigation, and upon it, at the present time, investigators are substantially in accord. It is, I think, generally accepted as proved that, by a considerable variety of methods, animal materials can be rendered sterile, and that danger of infection from their use is almost *nil*, or perhaps as nearly so as with any material at our command. While the question of sterilization has been closely studied, less attention has been paid to the behavior of these materials in the tissues, and little is known of their durability and of the length of time during which they retain sufficient strength adequately to hold the tissues in apposition. The views of surgeons differ widely in regard to the length of time during which their suture materials remain strong, and there is surprisingly little experimental evidence to be found upon this point. In view of this unsatisfactory dearth of information, the writer undertook an investigation to determine if possible the length of time during which catgut of various sizes and makes and of different methods of preparation retains its strength in the tissues.

It will, I think, be generally admitted that it is desirable that a suture material retain its strength for three weeks, and it is obviously unwise to use absorbable materials which are retained in the tissues much longer than is positively necessary. What we want in an absorbable material is that it shall remain strong for three weeks and then disappear as fast as possible, for where these materials are retained in the tissues for a great length of time, they are open to many of the same objections as the unabsorbable materials. We not very infrequently see catgut and animal tendon sutures

discharged through sinuses, showing that they have become foreign bodies, and that their absorption has been too slow to counterbalance the tendency of the tissues to sequester foreign material.

The process of absorption of catgut takes place by infiltration with round cells and polynuclear leucocytes, and the rapidity of the process depends largely upon the blood supply of the part. In tissues of poor blood supply and consequent low vitality, as subcutaneous tissues and fascia, the rapidity of infiltration is much diminished and absorption is therefore markedly slower, while in very vascular tissues the most rapid absorption takes place. These facts should be borne in mind in estimating the true durability of absorbable materials.

## METHODS OF INVESTIGATION.

In order to arrive as nearly as possible at uniform results, animals of the same variety have been used in all experiments, and sutures have been placed in an anatomically similar position. Rabbits were chosen because of their marked ability to withstand infection from the pyogenic organisms and on account of the ease with which they can be handled. For the benefit of our anti-vivisection friends, it may be here stated that all animals were completely etherized during the operation and were treated as surgical patients. All sutures were placed deep in the muscles of the hind leg, a region of free blood supply where absorption would be as rapid as in any part of the body, and were so arranged as to include a considerable bundle of muscular fibres and to be covered above and below by muscular planes. In order to have pieces of sufficient length to test their strength when removed, the gut was passed twice around the muscle selected and then knotted with the ends left long. The skin was closed with fine silk and a collodion dressing applied. Immunity from anything more than a mild skin infection was very marked, and in only three cases did any pus formation occur about the sutures. The materials used were plain catgut in sizes Nos. 0, 1 and 2, from makers Lee, Peak, Leavens, Van Horn and Countie. Chromicized catgut in the same sizes and from the same makers was also used.

## RESULTS.

Briefly stated, the results were as follows:

*Plain catgut.*—Prepared by heating under pressure in alcohol, a method very generally employed in the moist preparations. The strength of these materials when removed was estimated by an attempt to break them. When they could not be broken in short lengths of one and one-half to two inches, they were considered of full strength; when broken only with difficulty they were considered of good strength; when broken easily, worthless. No. 0, good strength at four weeks (two cases); No. 1, full strength four to six weeks (seven cases); No. 1, prepared by dry heat, nearly absorbed in three weeks (two cases);

<sup>1</sup> Read before the Surgical Section of the Suffolk District Medical Society, Jan. 8, 1902.

No. 2, unsterilized and not hardened, full strength four weeks (one case).

*Chromicized catgut.*—The following results include the product all makers considered together, as the methods of preparation do not differ widely. They are all prepared by the moist method and sterilized by superheating in alcohol in closed tubes; No. 0, little strength at four weeks (two cases); No. 0, moderate strength at six weeks (one case); No. 1, full strength five to eight weeks, present and of some strength eight to ten weeks (five cases); No. 2, full strength eight to twelve weeks, nearly absorbed sixteen weeks (four cases).

With a view to determining whether diminution in the strength of the solution of chromic acid or bichromate of potash would materially diminish the absorption time, some special gut was kindly prepared for me by Mr. Sampson, then with Countie & Co. Two sets were prepared, one with a solution one-half the usual strength for one hour as against the usual thirty hours, another with a solution one-quarter strength for one hour. These special preparations looked not unlike the regular material, but were somewhat lighter in color, though of the same strength and pliability. Both of these special preparations retained full strength for from three to four weeks as against five to eight weeks for gut prepared by the usual method (eleven cases).

The gut subjected to one-half strength solution retained some strength in the tissues from five to eight weeks (five cases), while that treated with one-quarter strength solution was absorbed in four to six weeks (six cases). These last experiments show that the catgut prepared with the weaker solutions retains its full strength for a somewhat shorter time, and that after the process of absorption has begun it is completed more rapidly.

Briefly stated, my conclusions are as follows:

(1) That in rabbits chromicized catgut of No. 1 size is retained longer than is desirable in a suture material for surgical use; (2) that plain catgut of No. 1 size is retained a sufficient length of time; that is to say, a minimum of three weeks; (3) that that catgut prepared by dry heat is more rapidly absorbed than that prepared by moist methods; (4) that the time required for absorption increases very rapidly with the increase of size, as No. 2 gut took from two to three times as long to absorb as No. 1.

The question that now confronts us is that of correlating these results with the requirements of operative surgery. It is not possible to obtain any large number of clinical observations on the subject of buried suture material, and we must therefore take advantage of a few isolated observations. I have at present in my possession a piece of No. 1 chromicized gut which was removed from an abdominal sinus seven weeks after operation, and which at that time was apparently as strong as when applied. I have in three cases removed ligatures of No. 1 plain catgut from the subcutaneous tissues at intervals

varying from one week to ten days, and in all three cases the gut was apparently as strong as ever. In a number of cases in which No. 1 chromicized gut had been used to suture the superficial fascia in a laparotomy in a thin patient, the knots of the suture have been felt under the skin apparently as plainly as at the time of operation, after intervals varying from four to six weeks. It has been my feeling that catgut sutures placed in the skin were more rapidly absorbed than when entirely buried in the tissues, and I find that the same impression exists among other observers, though no absolute evidence has been introduced. Through the kindness of Dr. Porter and the house staff of the Massachusetts Hospital I was enabled to obtain records of a number of cases in which No. 2 plain catgut was used as a continuous skin suture. This material was so completely absorbed that it could be wiped off without the use of force after an interval varying from eight to fourteen days. The conditions prevailing in mucous membranes appear to be favorable to rapid absorption, and in a few cases No. 1 chromicized gut placed in the cervix has been so far absorbed as to break on the least tension after an interval varying from seven to ten days.

The relation of these somewhat scattered observations may perhaps be rendered more obvious by a brief discussion of the reasons which may govern the choice of material in different regions. Catgut has its largest field of usefulness in the suture of wounds and as a ligature material for vessels of moderate size.

In the suture of wounds, the choice of size and preparation is of considerable importance, for the use of sizes too small will jeopardize the firmness of the scar, while the use of sizes too large gives rise to the danger of slow absorption and possible sinus formation, thereby forfeiting its superiority over silk.

Let us consider in detail the closure of an abdominal wound in layers. For the suture of the peritoneum where no tension exists and healing is rapid, size No. 0 or even No. 00 unchromicized will prove ample to retain the tissues in apposition until healing has taken place. The suture of the muscular layer where it has been split longitudinally, opens the question whether it is wise to suture this layer at all. The application of a suture including a considerable bundle of fibres subjects this portion of the muscle to pressure which will probably result in its conversion into fibrous tissue. This action is rendered more probable by the inevitable changes in the size of the muscle whenever the patient moves, and some muscular action is inevitable, especially during the nausea following operation. In this connection a case observed by Dr. C. A. Porter is of interest and importance. Appendectomy was done in December, 1900, by incision through the right rectus. The wound was closed in layers with chromicized catgut, the separated fibres of the rectus being brought together by chromic No. 1 catgut sutures, including a considerable bundle of fibres, and especial care was taken to see that the

sutures were *tied without tension*. In July, 1901, seven months later, the abdomen was again open for intestinal obstruction due to post-operative adhesions, the incision being made in the site of the former one. Those portions of the rectus included in the sutures applied at the previous operations were found replaced by fibrous bands one inch wide, thus converting the lower segment of the muscle almost completely into scar tissue and seriously impairing its function. This observation and several other less striking ones have served to convince me that atrophy of tissue included in a suture very generally takes place, and that it is unwise to anticipate any other result. If sutures coapting muscular edges are so placed as to include very few fibres, they are of little or no value in strengthening the wound or preventing the occurrence of dead spaces, as the fibres are so friable that the suture gets very little hold. If any sutures are used in the muscle, they should be of the smallest size of plain gut, so as to be absorbed in a few days.

The fascia is the layer of the most importance, and it is here that opinions will be found to differ most widely. The object to be gained is the union of this layer *without tension* by a material that will retain its strength for from three to four weeks. The use of catgut in sizes smaller than No. 1 is not to be advised, as it certainly will not come up to the requirements in durability. No. 1 chromicized gut will last sufficiently long and appears to satisfy the requirements as well as any material at our command. Many surgeons prefer to use larger sizes, as No. 2 or occasionally No. 3, on the ground that No. 1 is not strong enough. This objection seems to me unsound, because the demand for a stronger material implies that too great tension is being put on the sutures. No suture tied under much tension can be depended upon to maintain nice approximation, for it will inevitably cut out until this tension is relieved. This process of cutting involves a certain amount of necrosis of tissue, and the danger of wound infection is thus increased. I have seen reason to believe that some at least of the wound infections which have been thought due to the use of infected material have in reality been due to the lowered vitality of tissue included in too tight sutures. In exceptional cases, when No. 1 gut is not quite strong enough or it is desirable to use tension despite its obvious dangers, No. 1 gut may be used doubled, thus giving ample strength without increasing the time required for absorption.

What has been said above in regard to the use of catgut in uniting fascial layers is entirely applicable to the special fascia involved in the radical cure of hernia. In this operation wound infection is so serious a complication that every effort has been made to discover and remove every possible cause. Too great tension on the sutures, while not perhaps a primary cause of infection, is undoubtedly a predisposing element, and may be avoided by the use of suture materials which will not stand too great a strain.

As a suture material for the skin, catgut has only one great claim, namely, that it does not have to be removed. The process of cell proliferation by which it is absorbed results in the formation of more scar tissue than takes place about the nonabsorbable materials,—silk-worm gut and silver wire,—and therefore is likely to leave a less perfect scar. It also acts as a drain to the fluids in the tissues, and by thus keeping the wound moist renders the surface a more favorable site for the growth of bacteria. The redness which is often seen in skin wounds sutured with catgut is not, however, always to be considered as evidence of infection, for it is often but the visible evidence of the formation of new vessels to carry on the process of absorption. When, however, it seems desirable to use catgut in spite of these disadvantages, No. 2 plain gut can be relied on to last from eight to fourteen days, and seems to be the size most nearly satisfactory.

As a ligature material, catgut has come into very general use, and in the practice of some surgeons into almost universal use. Its rapid rise in popularity has been due, first, to the well-known tendency of silk to form sinuses, and, second, to the general acceptance of the belief in the possibility of rendering catgut perfectly sterile. The bar to its universal acceptance has been a fundamental disbelief in its safety when applied to vessels of any considerable size. This fear is in part well founded, but it has to my mind proved more of a barrier to the use of catgut than the facts justify. It will be generally admitted that when vessels of large calibre or large masses of tissue are concerned, the softening which takes place in catgut when in contact with moist tissues will make its hold less secure than that of silk. Where great pressure is necessary to occlude the vessels, catgut will not maintain a high degree of tension for a sufficiently long time. But this does not apply to vessels of medium or small calibre, or conditions where it is possible to avoid ligature *en masse*. The fault which has been found with catgut under these circumstances and the liability to secondary hemorrhage belong not always to the material, but to the manner in which it is applied. The danger of trusting to two knots when three would give perfect security, and of cutting the ends of the ligature too short, have not been sufficiently recognized. If the ends of a catgut ligature are left one-half, or, better, three-quarters, of an inch long, the danger of the knot untying is eliminated.

The choice of sizes and preparations for ligature material is regulated by much the same considerations as in the suture of fasciæ. Sizes larger than double No. 1 chromicized gut are rarely necessary, for they are retained too long and may lead to sinus formation. In cases where catgut is to be used to ligate vessels of the first calibre, the larger sizes must be used, but I believe silk is a safer material for this purpose. For use on small vessels, as in breast operations, the small sizes, No. 0 and 00 plain gut, are to be preferred,

as they are only needed for a few days and they are rapidly absorbed. It may be stated as a general rule that catgut should be used in sizes as small as will do the work required in any given case.

In conclusion I wish to emphasize certain points which seem to me of importance: (1) In order to get the best results from catgut, care must be taken to select the size and preparation best suited for each occasion; (2) the use of too large sizes is one cause of unsatisfactory results; (3) care in tying and cutting catgut ligatures is essential to safety.

### NEGLECTED METHODS FOR THE STERILIZATION OF "GUM-ELASTIC" CATHETERS.<sup>1</sup>

BY F. J. COTTON, M.D., BOSTON,

*Assistant Visiting Surgeon, Boston City Hospital; Surgeon to the Genito-Urinary Department, Boston Dispensary.*

IN regard to the methods to which I am to call your attention, I would say that they are in no sense original methods of my own. They were new to me when first found and have proved new to a number of men to whom I have spoken of them. These methods I have tested rather carefully and, believing that they deserve to be used, call attention to them.

The first method, that of Herman of Rydgier's clinic, was published early in 1901.<sup>2</sup> He had found that gum-elastic catheters and bougies could be boiled in a saturated solution of ammoniac sulphate without damage, not only for a few minutes, but for several hours.

Somewhat later Claudius of Copenhagen published an article,<sup>3</sup> the original of which I have not seen, stating that "silk" catheters could safely be boiled in concentrated salt solution. A reasonably extended search in textbooks and periodicals, for mention of these or like processes, resulted only in the finding of a passing notice by Alexander, in Morrow's "System," to the effect that gum-elastic instruments could be washed, then boiled in salt solution one drachm to the ounce, dried and dipped in boiling water before using. These three methods seemed worth testing, and have accordingly, especially the first two, been pretty thoroughly tested.

First, as to the ammoniac sulphate method. This salt,  $(\text{NH}_4)_2\text{SO}_4$ , may be gotten of the wholesale drug and chemical dealers at twenty-five cents or less the pound. It is evidently a by-product and very dirty. It can, however, be cleared by filtering the solution, or, still better, by letting it stand and decanting. The salt is soluble in one and three-tenths parts of water. This saturated solution boils in the open dish at  $227^\circ \text{F}$ . For actual use a slightly weaker solution was used. An ordinary open pan was used, over a rose-burner. (a) In the first experiment an ordinary cheap gum-elastic catheter was boiled in this solution two

hours at a time for a total of eight hours. It showed no change of surface or flexibility, though slightly darkened in color. (b) Next, three catheters were boiled for a half-hour, and let lie in the solution for two days without damage. (c) A mixed assortment of seven catheters, bougies and filiforms of various grades<sup>4</sup> were boiled for ten to twenty minute periods for a total of five hours. They were washed and dried between boilings. Only one—a bougie by no means new—showed a little cracking and roughening. (d) Next, two catheters and an old bougie were boiled three-quarters of an hour and let lie in the solution for twenty hours. The old bougie was a good deal roughened, the catheters intact. (e) A mixed set of catheters and bougies—all new—were boiled for fifteen minutes, absolutely without damage.

Like experiments were made with concentrated salt solution. Salt is less soluble than the ammoniac sulphate, but a saturated solution proved to boil at nearly the same temperature,  $227\frac{1}{2}^\circ \text{F}$ . None of the fifteen assorted instruments subjected to long boiling in saturated salt solution showed any damage, save one cheap black bougie, which blistered slightly.

The method of using 12% salt solution (1 dr. to 1 oz.) was tried only twice, but on these trials boiling for fifteen minutes failed to show any damage to the instruments used.

Most of these experiments were carried out over six months ago, and most of the instruments used were kept, to watch for any late effects. There were none, except that instruments which were cracked before the experiments showed a recurring deposit of feathery crystals at the crack. This, however, like the crystals that form at the eye of catheters so boiled, is readily washed off and leaves no defect behind.

As a result of these tests, I am ready to claim that all the gum-elastic catheters, bougies, and filiform bougies ordinarily sold may be boiled repeatedly and for long periods in saturated (or something less than saturated) solutions of ammoniac sulphate or sodic chlorid without essential damage. New instruments show no damage whatever, used instruments only a deterioration that is of no great consequence. As to a choice between the two, I feel a little surer of the ammoniac sulphate, perhaps, but would choose it not so much because of this as because it is easier to handle and spatters less when it boils down than does the common salt.

As to the weaker solutions of common salt, they seem to be all right, but the tests made are too few as yet to be conclusive. At all events, the use of these more dilute solutions has no obvious advantage and has the disadvantage of lowering the boiling point.

It will be generally admitted that the use of gum-elastic instruments has been limited by the inefficiency of methods of sterilization, and that

<sup>1</sup> Read before the Surgical Section of the Suffolk District Medical Society, Jan. 8, 1902.

<sup>2</sup> *Centrbl. f. Chir.*, 1901, H. 3.

<sup>3</sup> *Hospitallstidende*, 1901, vol. 4, p. 515, Nos. 13-16.

<sup>4</sup> It seems impracticable to ascertain the ultimate source of many of these instruments. Suffice it to say that all obtainable sorts were tried.