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THE TECHNICS OF THE BURIED TENDON SUTURE

—MARCY

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BY

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THE TECHNICS OF THE BURIED TENDON SUTURE.*

The constant receipt of letters from all parts of the country, containing inquiries concerning the method for the safe use of the buried animal suture, prompts the writing of this brief contribution. At the risk of seeming dogmatism, I venture to assert that aseptic wounds, with very few exceptions, should be primarily closed by buried tendon sutures and hermetically sealed with iodoform collodion.

To accomplish this the surgeon must be master of the technics of aseptic surgery. Without it the buried animal suture should never be used. Under aseptic conditions this suture may be safely applied with the assurance that the collodion seal is a guarantee of subsequent non-infection. Other suture material may be employed—as, for example, silk, silkworm gut, silver wire, etc.—with the certitude that it is non-infective when properly applied, and that it will maintain the structures in coaptation for an indefinite period.

* Read before the Southern Surgical and Gynæcological Association at its eighth annual meeting.

I need, however, only refer to the general consensus of opinion that these materials are objectionable because of their non-absorbability, and that too often such sutures become a source of subsequent irritation and discomfort, not seldom being eliminated as foreign bodies. To avoid these results the animal suture has received wide adoption. This was found ready at hand, seemingly well adapted to the purpose, in the catgut of commerce. Smooth, even, strong, in varying sizes, what could be more satisfactory? It was soon discovered, however, that it was difficult of sterilization, and, as usually prepared, did not remain sufficiently long intact in the structures. Hence has arisen a great variety of methods of preparation. The defect, however, is inherent in the structure itself.

It must be remembered that catgut is the connective-tissue sheath of the small intestine of the sheep. In order to separate it from the other intestinal coats, the intestine must be subjected for a considerable period to the decomposing processes of putrefaction. This is accomplished by the bacterial growths which develop in its maceration, attacking the connective-tissue sheath last as the most resistant. When this process is held in abeyance, and the fibrous coat of the intestine has been cleansed, it is found to consist of a thin layer of connective-tissue bundles which interlace obliquely in order to permit the physiological foreshortening and expansion of the intestine. The cement substance which holds the cells together has been more or less injured by the process of maceration, and the entire structure is everywhere replete with bacterial growths.

Longitudinal division leaves flat bands of this tissue which are twisted into strings of varying thickness, the catgut of commerce. When dry, this is very strong and tolerably inelastic; but when wet, as for example, when buried

in the tissues of the body, it speedily becomes a soft, flattened band of elastic structure, a condition which easily explains the unsatisfactory use of catgut in surgery, almost regardless of the processes of preparation to which it has been subjected.

In the tendons of animals the connective-tissue cells are disposed in an entirely different manner and for quite another physiological purpose in the animal economy. Here the fibrils are placed in parallel bundles, held together by the cement substance for almost the sole purpose of strength. When they are of any considerable size, a few lateral fibres are interspersed for the purpose of holding the bundles together in a single mass. It is on this account that a tendon is weakened by subdivision, and when it is too minutely divided it may become worthless for the purposes of strength because of the fraying out of these lateral fibres. Tendons subjected to maceration like catgut become speedily damaged, because of the softening of the cement substance which holds together the connective-tissue cells, and under these conditions, like catgut, the tendon is easily ruined.

Carefully selected tendons are to be preferred for buried sutures, since primarily their anatomical construction makes them stronger, more compact, and, as a consequence, more resistant to the softening processes which must ensue when buried in the living structures.

Secondly, when properly preserved, they have never been subjected to bacterial decomposition, and hence they can be sterilized without detriment to their ultimate elements. Such tendons serve a very good purpose as sutures when taken directly from the freshly killed animal. This, however, is very rarely convenient, and therefore some process of preservation must be resorted to. If they are quickly sun-dried and kept dry they can be preserved for a long

period, since bacteria can not develop without moisture. This has been the custom indefinitely among the Indians in the preservation of their tendon suture material, which has been the thread of the savage since the beginning of history.

Although many surgeons use them preserved in a dry state, and when ready for application soaked until supple in some antiseptic, the sutures, even if aseptic, soften too quickly in the tissues.

Time does not permit a review of the various processes which have been recommended for the preservation and preparation of the animal suture. Perhaps the more common method has been to preserve it in alcohol alone or combined with other substances. When subjected to dry heat, to boiling repeatedly in alcohol, or under pressure, the connective-tissue structures are rendered sterile, but they are seriously damaged in their inherent composition, both in the connective-tissue cells and in the cement substance which holds them together.

Profiting by the experience of the ages in the manufacturing of skins into leather, astringents in combination with oils have been experimented with, and in many ways most satisfactorily. This is largely the advantage obtained in the use of chromic acid, which, by a kind of hardening process, tans the tendon—that is, fixes the cement substance, holding the cells in more permanent apposition, and renders it far more resistant to the macerating effects of fluids. Hence, chromicized catgut or tendon undergoes change much more slowly when buried in the living tissues.

The difference in structure of the two substances already referred to is easily shown by the simple immersion of catgut and tendon, similarly prepared, for half an hour in a warm fluid—as, for example, in a 1-to-1,000 solution of bichloride of mercury. The catgut becomes swollen,

slippery, can be threaded with difficulty, and when tied the knot holds very imperfectly. On the contrary, the tendon is supple, firm, inelastic, does not kink, and is manipulated with an ease and satisfaction unknown to one who has used only silk or catgut. When tendon has been chromicized it is best preserved in a sterilized oily fluid. Experience has shown that by far the best preserving fluid is linseed oil sterilized by heat, to which carbolic acid has been added. Tendon improves with age, so much so indeed that I rarely use it until it has been thus kept in the oil from three to six months.

A method far too common has been to preserve chromicized catgut and tendon in absolute alcohol, boiled under pressure. There is no question but that such material is absolutely sterile, but the important factor has been singularly overlooked that by this process the chromic acid is dissolved out of the tendon, thereby leaving it really less valuable than if chromic acid had not been used.

There remains the vital question to be answered, How may the surgeon be assured that the tendon suture in itself is not a source of infection? Primarily, that it has been taken from a freshly killed animal, that the said tendon has been quickly sun-dried, and kept dry until ready for preparation. This consists, first, in soaking the tendon in a solution of 1-to-1,000 bichloride of mercury until supple. Then, carefully separate each tendon individually and dry separately between sterilized towels. They are then assorted into small bundles and chromicized with the greatest care in a 1-to-20 watery solution of carbolic acid to which has been added one four-thousandth part of purified chromic acid. This will prepare tendon of equal weight with the crystals of carbolic acid, but the tendon must be immersed in the solution immediately upon the preparation of the fluid, since otherwise in a short period

the chromic acid is thrown down as a sedimentary deposit. The process of chromicization goes on more or less rapidly, dependent upon heat, exposure to sunlight, the quantity of material manipulated, and requires careful watching, since, if too rapidly effected, or permitted to remain too long in the solution, the tendon may be easily ruined. When properly chromicized the tendon should be of a dark golden color. When taken from the chromicizing fluid the tendon is best dried in the sunshine between sterilized towels, and should be immediately put up in carbolic oil, the whole process carefully conducted under aseptic conditions, the bottles securely corked and sealed. When wanted for use the tendon is carefully taken from the bottle, soaked in a mercuric solution until supple, and then arranged in parallel strands, wrapped in a folded towel saturated with a 1-to 1,000 mercuric solution, the ends of the tendons exposed so that they may be withdrawn one at a time as selected. If more convenient they can remain immersed in a dish of bichloride solution during the operation and selected therefrom as required. The amount of the bichloride contained in the suture does no harm to the structures in which it is buried. I have often thought it an advantage rather than otherwise.

A brief reference to the history of the buried suture may be interesting. It is known that the Greeks and Romans used the strings of their musical instruments for various purposes in surgery. The first reference which I find to the use of the animal ligature was by Dr. Physick, of Philadelphia, who in 1806 suggested that such material should be of value. Dr. Physick first published upon the subject in 1816. He recommended the ligature to be made of chamois or buckskin, variously prepared. For a considerable period his method seems to have been widely adopted. Dr. McDowell tied the pedicle in his first ovari-

otomy with buckskin, returning the same to the abdominal cavity, and closed the wound without drainage.

The best article which we have extant of this period is a prize essay, written by Dr. Jameson, of Baltimore, bearing the date of 1827. He made numerous experiments upon the lower animals, and recorded his observations with a care and skill worthy of any scientist. For a considerable time animal ligatures were used in London by Sir Astley Cooper and others; but in the subsequent period of heated debate upon the so-called processes of inflammation supervening in wounds this most valuable experience was lost to science and forgotten until repeated in our own time by Mr. Lister. His experimental studies are in large measure a repetition of those of Dr. Jameson, but occurred in a more fruitful age, the knowledge of the bacterial infection of wounds reducing to known terms the mysteries of the inflammatory processes so long discussed by the surgical masters.

In 1870 it first occurred to me that the separated structures in healthy wounds might be advantageously joined by coaptating the same with ligatures precisely as I had seen Mr. Lister ligate arteries. I used interrupted catgut sutures cut short and left deeply buried in the wound. I soon found it more convenient to use a continuous suture. After a time I ascertained the defects of catgut, and in 1880 I first published my experience in the use of tendons from various animals, that from the hind leg of the moose proving perhaps the best. After a long search for better material, judging from the anatomical structure of the tail of the squirrel and opossum, I sought for the tendons from the tail of the kangaroo, and received my first invoice in 1882. The superiority of these is found in that the psoas muscles subdivide in numerous fasciculi, each of which has its own separate tendon. These continue in separate parallel

strands, like a skein of threads, to their attachment to the very end of the tail. The anatomical picture is found in the tail of the rat and of the squirrel. These are, however, too short and fine for general use. On the contrary, the tendons from the tail of the large kangaroo (*Macropus giganteus*) are many times too large, and when subdivided are liable to split flat and fray. Only recently has my attention been called to tendon of this character which is being sold for suture material. The smaller varieties, called by the natives the *wallaby*, furnish excellent tendons in variable sizes without subdivision, and are the ones to be preferred.

The aseptic suture, buried in wounds which have been made and maintained aseptic, approaches nearer to the ideal than any other material yet in use. By it all wounds in healthy tissues, no matter how large, even the major amputations, should be closed securely, like structures joined without recesses or pockets, thus doing away with drainage in any form. This prevents the need of expensive absorbent antiseptic dressings and permits of a germ-proof seal of iodoform collodion. Subsequent infection is *then* impossible.

The method of the application of the suture is of some importance. It should be continuous, since less material is required in the wound, knots are avoided, and the tension upon the structures is equalized. This last is very important. Coaptation, retention, and rest are the factors. Undue constriction of the tissues devitalizes the parts and is to be carefully guarded against. If much strain is likely to ensue upon the coaptated parts, I usually use the double continuous suture, which I commended to the profession many years since, applying it by means of a needle with eye near the point, so that the suture passes in opposite directions through one opening or puncture in the same manner that the shoemaker carries his bristled thread. It

is, however, important to remember we are only to *coaptate* and *not* to *constrict* the structures by such powerful measures. The Hagedorn full-curved needle is very convenient, since it serves as both needle and handle, and can consequently be best used without a needle holder.

The end of the suture fastened by a slip knot, the needle is deeply buried in the structures to be coaptated, from side to side, each stitch entering directly opposite the emergence of the preceding stitch; when the suture is drawn upon, the tendon crosses the wound at right angles and leaves its lips in secure coaptation, with *no foreign substance* intervening. This is impossible in the application of the buried interrupted suture. The skin is closed by a fine tendon suture, taken in a similar way, puncturing only the deeper layer (subcuticular suture). This I devised and have used it almost daily for the last ten years, designed to avoid stitch abscesses, long before it was known that our most dangerous enemy was a micrococcus ever present in the dying epithelium of the skin.

The larger vessels are better ligatured with fine tendon, not too tightly, however, always remembering simple constriction to prevent bleeding is sought, not necrosis of the inclosed vessel. A wound thus coaptated does not bleed. The serous exudate is at once followed by cell proliferation, and the repair processes supervene with a rapidity understood only by those familiar with the histology of aseptic wounds placed at rest. The suture thus buried in healthy tissues is first surrounded by leucocytes, then slowly invaded by them. Little by little these are changed into connective-tissue corpuscles, and the tendon is finally replaced by a living band of connective tissue, a re-enforcement of vital importance in many wounds—*e. g.*, hernia, laparotomy, suturing of tendons, muscles, etc. The iodoform collodion seal has many advantages. If the structures

below have been aseptically joined there is no subsequent possible infection. It holds the cutaneous surfaces in fixation, retention, and at rest. The repair processes which ensue beneath the seal are so minimized that the scar is in large measure avoided; a result in itself comparatively a minor matter, not to be overlooked, since a tender cicatrix is a source of discomfort and generally unsightly. The subsequent bandaging is also minimized, often omitted altogether. In this there is a manifest gain in comfort to the patient, saving of expense in material and care, and, most of all, the doing away with the still too common custom of making pressure upon the wounded structures for the purpose of securing coaptation and controlling the escape of blood and serous exudation. Compressed tissues are more or less deprived of the free circulation of the blood upon which their nutrition depends and without which repair is impossible.

The coaptation of sundered aseptic structures by the use of the buried aseptic tendon sutures, and their fixation, retention, and rest under an aseptic seal without compression, is the corollary to antiseptic surgery, and should be adopted by every competent operator.

In the long series of my experimental studies upon animals in which, under varying conditions, sutures have been buried, I was at first led to believe that the connective-tissue cells of the buried material were, in a measure, revivified, as in a graft, so accurately did the living band of connective tissue replace the implanted suture. More careful studies, however, show that the foreign material is at first incapsuled by cell proliferation which, little by little, invades it, causing its disappearance precisely in the same way as necrotic tissue disappears after injury, where the surrounding parts are maintained aseptic.

I here call your attention to microscopic slides show-

ing sections of the tissue surrounding buried tendon sutures at varying periods after their implantation. It will be noted that the thicker portions of the tendon are distinctly traced, even at the lapse of a year or more, centrally imbedded in a firm stroma of healthy connective tissue.

Elsewhere I have published at length the clinical reports giving statistical results.

In over two hundred laparotomies, where the abdominal wound has been closed with buried tendon sutures applied in separate layers, but two cases of subsequent hernia have been noted: one the result of infective sloughing, the other after the removal of a large fibroid tumor, where, rather than a hernia proper, the whole abdominal wall was left relaxed and bulging.

In over three hundred cases of operation for radical cure of hernia, where by means of buried tendon sutures the posterior wall of the inguinal canal has been re-enforced and strengthened and its obliquity restored, more than ninety per cent. have remained permanently cured.

The infection of wounds may never be absolutely prevented, but the experience of surgeons teaches us daily to what a marvelous extent it can be minimized, reduced in aseptic wounds, I confidently believe, even in hospital practice, to less than five per cent. Indeed, not long ago I examined my own personal experience, reviewing six hundred operations upon aseptic structures with only two per cent. of septic cases—evidence, I think, ample to show the safety of the coaptation of wounds by the buried animal suture. I am confident that at an early period the use of the buried tendon suture in aseptic wounds will become indispensable in operative surgery.

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