my patients. The justification, in my opinion, will still hold good, even if some of the cases now classed as cured should relapse, or in the future become the victims of a new nephritis.

Of the entire 102 patients, therefore, 21 received no benefit from operation, while 81 patients experienced amelioration varying all the way from slight and temporary improvement to complete cure. In 12 cases the operation proved directly life-saving by rescuing the patient from impending death.

In judging the above results, the fact should be borne in mind that the immense majority of my patients came for operation only after all other measures and treatment had failed to arrest the progress of their chronic nephritis. A great number were on the very eve of dissolution, and the desperate character of my series of 102 cases will probably not be duplicated by any surgeon in the future. Better results than those recorded here will undoubtedly be obtained as soon as sufferers from chronic nephritis seek relief and cure in early operation.

In the meanwhile, these results, 33 cures among 99 patients whose ultimate fate is known—obtained in a hitherto incurable malady, and one which, according to the United States census of 1900, ranks sixth in the list of diseases causing death, not alone justify the surgical treatment of chronic Bright's disease, but establish that treatment as at present the main if not the only hope of a very large class of sufferers.

For the present, in view of the helplessness of medicine in the presence of established chronic Bright's disease, the advance in treatment represented by renal decapsulation should be welcomed by every physician called upon to treat chronic nephritis. Nor is the physician justified in taking the position that only after all other measures have failed will he resort to decapsulation. That is giving neither the operation nor his patient a fair chance, to which the latter at least is certainly entitled. For even at present I am able to affirm, as the result of experience, that renal decapsulation applied early in the course of a chronic nephritis, and in the absence of complications, is almost free from danger in expert hands, and is almost a certain cure.

That physicians are not unwilling on occasion to try in their own persons methods of treatment which promise more than those heretofore known to medical science, seems indicated by the fact that of my 102 patients no less than 14 were physicians, and 5 others were members of the immediate families of physicians. One physician and his wife were both operated on during the same afternoon.

Much of what has been said in this paper rests upon the assumption that the curability of chronic Bright's disease by decapsulation of the kidneys is a proved fact. Regarding it as such, I feel that my expectation and hopes of years ago have been in large measure realized, and that the promise of a yet fuller realization appears bright.

12 West Fiftieth Street.

The Dark Ages of Tuberculosis to End.—I have lived through many of the long, dark years of ignorance, hopelessness and apathy. . . . But I have lived also to see the dawn of the new knowledge, to see the fall of the death rate of tuberculosis, to see hundreds who have been rescued, to see whole communities growing up of men and women whose lives have been saved and who are engaged in saving the lives of others.—Dr. E. L. Trudeau.

THE SUTURE: ITS PLACE IN SURGERY *

HENRY O. MARCY, M.D.

BOSTON

The history of the ligature and the suture is, in a measure, the exponent of the history of surgery. Surgery may also be accepted as a fair exponent of the rise, fall and progress of civilization.

PREHISTORIC SURGERY

Always prominent in the very dim and shadowy past, two of the professions, with which the third is more or less intimately blended, come into bold relief. In the differentiation of duties, even in the tribal relations, there was set apart a liberal representation of the brighter intellects for determining the relation of man to his brother and to that which all men have believed more or less clearly, the possible after-life. The rules of living determined by these men assume more or less formal expression in the codes of laws of the state and the church. The physical needs of mankind became at once apparent, and these were ministered unto, in differentiation from either spiritual or political needs by the so-called medicine-men of the savage tribes and priests and soothsayers of the barbaric ages. The need for the care of wounds and injuries produced a class of those especially trained, who have been denominated surgeons.

GREEK AND ROMAN SURGERY

Homer clearly portrays the active, beneficent service of the military surgeon. The fragmentary history of the Egyptian and Assyrian civilizations clearly teaches the honorable part assigned to his service. Pompeii, although a suburban city, has yielded abundant evidence of the surgeon's art in both war and peace. Pompeian frescoes portray his service. The instruments which he used are seen to-day in the great museum at Naples in considerable variety. This is as would be expected, since the mental processes act ever in the same accord, and a recognized need stimulates the meeting of the demand.

Roman civilization reached the climax of development in the early centuries of the Christian era, but, as in the case of Egypt, Assyria and Greece, unfortunately, many most important questions in regard to the development of the arts and sciences can at the best be only partially answered, since the storehouses of the most precious knowledge of the Romans were destroyed with the downfall of their civilization. We know, however, that even to-day we may learn much from the civil code and military regulations which dominated Rome's highest development. In both the civil and the military service the surgical profession was honored and the service rendered was of most signal value.

ANCIENT USE OF THE LIGATURE

The ligature played an important part in the armamentarium of Roman surgeons.

Celsus, living in the first century, one of the most remarkable of the Roman surgeons, gives special directions as to the use of sutures in a great variety of surgical affections. In illustration may be cited the pene-

* Read in the Section on Obstetrics and Diseases of Women of the American Medical Association, at the Fifty-ninth Annual Session, held at Chicago, June, 1908. Because of lack of space the article is here abbreviated by the omission of a history of sutures, but the complete article appears in the Transactions of the Section and in the author's reprints.

tration of the sac in the umbilical hernia of children with a needle armed with a double thread, the ligation being made on either side by close knots. Celsus described the ligature as of ancient origin and stated that it was used by the Alexandrian school of medicine, with the teachings of which he was apparently familiar.

Galen (131-201 A. D.) tied arteries on living subjects and experimented on animals to show the circulation of the blood. He foreshadowed the discoveries of Harvey and demonstrated by the double ligature of the artery on living animals that the artery contained blood and not air. For a variety of surgical purposes he ligatured arteries in continuity, but not in amputations.

AMBROSE PARÉ

Ambrose Paré was born in 1517. In 1552 he first tied the vessels of the leg in amputation. This brilliant man was then a surgeon in the army at the beginning of his notable career. Like many other notable discoveries, this was born of the inspiration of the moment. A prominent member of his own staff was severely wounded in the leg and Paré writes: "I had to finish the cutting of it off, which I did without applying hot irons."

One is almost tempted to stray from the subject of this paper in his sympathy for the great innovator, who, like many since his day, struggled against conservatism. It would be interesting to outline the battle royal which Paré fought to establish the principle and practice of the ligation of arteries in amputations.

Paré's one monumental contribution to surgery, his great book, lies open before me as I write. My copy, bearing date 1582, is in its original binding of calf, once held together by clasps. On the fly-leaf are the autographs of distinguished previous owners, and although in good preservation, its pages bear evidence of frequent use.

Paré's later life was crowned with many honors. He writes:

God is my witness, and men are not ignorant of it, that I have labored more than forty years to throw light on the art of surgery and bring it to perfection, and in this labor I have striven so hard to attain my end that the ancients have nought to excel us save the discovery of first principles; and posterity will not be able to surpass us (be it said without offense) save by some additions such as are easily made to things already discovered.

PARÉ'S INTRODUCTION OF THE LIGATURE FOR ARTERIES

The fact that Paré did succeed in establishing on a firm basis the innovation of tying wounded arteries is far more noteworthy than would at first appear, since it also changed the mode of dressing of the wound. At this period gunshot wounds were treated with boiling oil, in the belief that the gunpowder in some way acted as a poison in the wound. It will be noted that the cauterizing effect of the boiling oil, although producing most agonizing suffering, caused the primary sterilization of the wound, and that there was an abundant leucocytic proliferation beneath the necrosed layer, which in a measure prevented subsequent infection.

VESALIUS AND HEISTER

Vesalius in the sixteenth century mentioned the ligature as a relic of the past, greatly underestimated in value because of the lack of anatomical knowledge.

Heister's Surgery was the text-book of continental Europe for two generations, and its study to-day will richly reward any student who would be the thorough master of his profession. In his last edition, 1739, he writes:

The necessary apparatus for dressings seems by no means complete without Ligatures; Chords, Bonds and Strings, and these of different sorts, some fine, others coarse, strong, made either of flax, or hemp, or cloth, or silk, or horsehair, according to the nature of the disorder; for these things are almost constantly required.

HUNTER'S LIGATION OF EXTERNAL CAROTID

In 1785 John Hunter tied the external carotid in a buck. The antler of the side became cold, and he debated of its future existence; later it was warm and well nourished. Two weeks after, he killed the animal and found the ligature in place and the artery occluded, but the collateral circulation was increased so that the nutrition of the antler was restored. This was the foundation study which led to his advocacy and practice of the ligation of arteries for the cure of aneurism.

Dr. Wright Post of New York, one of Hunter's students, in 1796 performed Hunter's operation, the ligation of the femoral artery in aneurism, and in 1813 he successfully ligated the external iliac, the second operation of its kind to be performed.

HAIRE'S MODIFICATION OF THE LIGATION

Mr. Haire of England,¹ in 1786, introduced the method of cutting off both ends of the ligature applied to the artery close to the knot and letting the wound heal over it. This method was practiced by a considerable number of surgeons, but very naturally fell into disuse, because it was decidedly the exception to have primary union, since the wounds, as a rule, became infected.

LIGATURE MATERIALS

Ligature materials, linen and hemp, were known and used for a great many purposes at a very remote period, antedating written history. Flax ready prepared for spinning has been found with the remains of the cave-dwellers of Europe. Silk was used in China for centuries before the Christian era. The beautiful fabrics of the far East were in use in Rome during the first century and were often sold for an equal weight in gold. Cotton was cultivated in Egypt during the period of its early civilization. The surgeons of the early periods were furnished with a variety of material for ligature almost equal to the present.

In the Odyssey the strings of the old Greek harp are described as made from the twisted intestines of sheep. It is extremely probable that these strings were manufactured as the catgut of to-day is, since it is the connective tissue sheath of the intestine only which could have furnished suitable material. The ancient Egyptian harp is said to have been strung with a similar material. The celebrated Arabian writer Rhazes, who practiced surgery in Bagdad A. D. 900, described the stitching of wounds of the abdomen with the strings of the harp, and Albucasis describes the stitching together of wounds of the bowel with a fine thread made from the twisted intestine of an animal.

INTRODUCTION OF ANIMAL LIGATURES

More recently, the animal ligature was introduced by Dr. Physick of Philadelphia, in the year 1806, but no account of his experience was published until 1816. The history of its uses is a most interesting chapter. The surgeons for a generation in America, and to a less degree in England as well, ligated arteries extensively with absorbable material.

1. Hennen, John: Principles of Military Surgery, ed. 2, p. 181.

HORATIO GATES JAMESON

The profession is indebted to the really monumental scientific studies of Dr. Horatio Gates Jameson of Baltimore, one of the leading surgeons of the period.² His experimental studies were in a very large measure duplicated by Lord Lister a generation later. There is abundant evidence that Dr. Jameson was a singularly clean surgeon. His basic studies were made on various animals, and nearly all the wounds were evidently uninfected, since primary union was decidedly the rule. I have been at large pains to follow in detail the history of this extraordinary man as a surgeon, and I judge from his reports that it was the exception that suppuration ensued in his operative wounds made in fairly well vitalized structures.

Few men did so much to give credit to early American surgery as Dr. Jameson, who, from 1820 to 1840, carried the fame of Baltimore as a seat of medical and surgical research to all parts of the civilized world. This truly great surgeon was born in York, Pa., in the year 1778. His father, David Jameson, also a physician, had a most interesting and adventurous career. A native of Scotland and graduated doctor of medicine at the University of Edinburgh, he emigrated to Charleston, S. C., in 1740. He was accompanied on the voyage by Dr. Hugh Mercer, who settled at Fredericksburg, Va., and became a brigadier-general in the Continental army, losing his life, as is well known, at the battle of Princeton, in 1777.

Dr. David Jameson removed from Charleston and settled at York, Pa. He died at Shippensburg, in the same state, about the close of the century. He was a lieutenant-colonel in the French and Indian war and was badly wounded during that period in an engagement with the Indians. During the revolution he was colonel of the third battalion of York County Association. In 1842 the son gave a charming description of his home at York, in a Baltimore periodical; also an account of his father's voyage across the Atlantic, describing, among its hardships, the short allowance of musty bread and foul water and the rusty salt beef doled out, yet consumed by crew and passengers with avidity.

Dr. H. G. Jameson studied medicine under his father and began practice in 1795, at the early age of seventeen.

During the war of 1812 he held the office of surgeon to the United States troops at Baltimore, for which service his widow received a pension after his death.

He was physician to the city jail for several years; from 1814 to 1835 he was surgeon to Baltimore hospital, and from 1821 to 1835 he was consulting physician to the board of health.

In 1830, on special invitation, he visited Europe, sailing by the packet running from Baltimore to Germany, and read before the medical section of the Society of German Naturalists and Physicians, which met in September of that year at Hamburg, a paper on the "Noncontagiousness of Yellow Fever." He was the only American delegate on this occasion and the first American to attend these meetings, and he felt deeply the honor of his position. His paper was read in translation at the meeting and was published on his return, in his journal. During his brief stay of two months in Europe he traveled through various European coun-

tries, staying longest at Copenhagen, to the American representative at which city he bore dispatches from our government at Washington.

In 1835, while on his return from Texas, where he had purchased lands, he received and accepted an offer of a chair in and the presidency of the Ohio Medical College, at Cincinnati. His colleagues there were Drs. Gross, Drake, Rivers and J. B. Rogers, the last his late colleague at Baltimore. He removed thither with his family in October, 1835, and lectured during the ensuing session.

During a visit to New York he was taken suddenly ill, and died, Aug. 24, 1855, aged 76 years. His remains were brought back to Baltimore cemetery, corner of Gay street and Boundary avenue.

NEGLECT OF ANIMAL LIGATURES

I have gone to some pains in tracing the history of the ligature, since, in the light of modern knowledge, it teaches the reasons for success or failure in the treatment of wounds, all dependent on the then unknown factor of infection. This, in a general way, was in a measure understood; but the key which seemed at one time to lead to success appeared again to be utterly lost in the learned dissertations on inflammation—a condition which seemed inevitable in the repair processes of wounds. Thus it came to pass that the animal ligature was discarded and forgotten.

LORD LISTER

Based on the monumental labors of Lord Lister, surgery has been brought to its present perfection by a contribution of scientific workers. We all point with pride equal to that of Paré and sometimes wonder what may be left to our successors for contribution of equal value. Lord Lister attained the end sought, but by means which now seem in large measure superfluous. He made and maintained a wound in an aseptic state, and in very large degree taught us the reason why. He was slow to discard the use of drainage, which seemed to him essential, and for a long period his sutures, although of catgut, were interrupted, taken through and through the parts to be united, but always to include the skin.

When I was his pupil in 1870 he pointed out to us—an observation which I am sure was original with him—the active cell proliferation in the deeper layer of the skin. He often showed us that the imbedded suture at this point was frequently nearly divided, when the portion in the deeper part of the wound showed little if any change. He also called attention to the developing colony of bacteria which usually penetrated only the superficial layers of the skin, the stitch abscess. In this way he in a measure foreshadowed the later contributions of great value which demonstrated that bacteria of certain varieties were normally present in the layers of the skin, especially in the sweat ducts and hair follicles. Here they undoubtedly play an important physiologic rôle in the proliferation and destruction of the dying exfoliating cells—an instance of rare temerity on the part of Nature, who harnesses into her service a most potent enemy, which in other relations may cause death. Here the *Micrococcus pyogenes albus* plays a rôle of importance, yet as a possible active enemy, equaled only in danger by that of the *Bacillus coli communis* transposed from within its normal habitat in the intestine.

2. A Brief Sketch of One of Baltimore's Greatest Men, Horatio Gates Jameson, M.D.: His Most Valuable Contribution to Surgery: The Occlusion of Arteries by the Buried Animal Ligature. Henry O. Marcy, M.D., Trans. Southern Surgical and Gynecological Assn., 1906.

REASONS FOR NEGLECT OF ANIMAL SUTURES

When we recall the multiplied experiences of a very considerable number of America's most distinguished surgeons with the use of the animal ligature, and the frequent publications on the subject extending over a quarter of a century and incorporated into a number of prominent text-books on the surgery of the time, we are confronted with two important queries.

First, how could this method of the ligation of the arteries so soon have fallen into disuse?

Second, how was it possible that a subsequent generation could have been so absolutely ignorant of such a wide experience published and republished in both America and England?

The first question is easy to answer. Wound infection was the rule, and when infection occurred the selection of ligature material was a choice of evils. The silk ligature, with one end cut off and the other to serve as a drain, was generally adopted. To Lord Lister is undoubtedly due the honor of having reintroduced the animal ligature into surgical practice—on an entirely different basis, however, since he was the first to show that wound inflammations were caused by the introduction of something from without which acted as a ferment, and that that something consisted of very minute organisms of a low order, which reproduced and which were the cause of the so-called wound inflammations. This having been made clear and the demonstration ample that necrosed tissues in subcutaneous wounds were absorbed, it followed as a sequence that animal tissues applied about an artery in the form of a ligature might also be carefully disposed of by absorption, and hence we find, under a new stimulus and with a new reason, Lord Lister paralleled the experimental studies of Dr. Jameson, of which he was ignorant.

LISTER'S EARLY TEACHINGS

Early in 1870 I had the good fortune to become the first American pupil in Edinburgh of Mr. Lister, afterward Lord Lister. He was then comparatively unknown. I sought to profit by the instruction of the famous Professor Syme and thus learned that Mr. Lister had married the daughter of Professor Syme. This distinguished man died during my residence in Edinburgh. I was warned not to make the acquaintance of Mr. Lister, since he was considered an enthusiastic believer in a surgical heresy. Men who should have been his best supporters in the university would not recognize him.

I thought I knew surgery. I had had a large experience as a surgeon and medical director in the Civil War. For some years I had been a postgraduate student and instructor in Harvard Medical College. For the previous year I had been a student in Berlin under the celebrated professors Virchow, Martin and Lagenbeck. Here was a comparatively young, obscure Scotchman, who demonstrated to me daily that severe wounds might be made with impunity in almost any part of the body, and compound fractures recover without inflammation with the same safety as simple ones. I shall never forget my first morning with Mr. Lister in the old Edinburgh infirmary, where he showed me three resections of the elbow joint in children, in which the repair processes were going on without edema, pain or fever. Arteries were ligated with seeming impunity, and even the knee joint, hitherto the dread of all surgeons, was opened with safety. Fortunately my knowledge of surgery was sufficient to teach me the value

of these new demonstrations, and with notebook in hand I followed the master with daily increasing admiration and profit.

It is true that we now look on many of Mr. Lister's early procedures as cumbersome and unnecessary. Results, however, furnish the criterion of success. In these he was not wanting. The carbolic acid incorporated in the lac-plaster as a wound dressing was soon discarded. The carbolic spray, for good reason, was discontinued. The spray came near being the ruin of Mr. Lister's reputation and wrecking of the whole system of antiseptic surgery. This was made the most of by Mr. Lister's personal opponents, who would see in it the only contribution that Mr. Lister had attempted to make to surgery, purposely ignoring the scientific principles on which he sought to base the new teaching and that the spray was simply recognized as a means to the end of preventing infection during the operation.

"Away with the spray," said his rivals in London, who looked on his advent there only with a jealous eye. "Fort mit dem Spray," reëchoed his German adversaries, who at the time accepted grudgingly any contribution from France or England. American critics took up the refrain, and the new teaching can hardly be said to have been established in a general way until after the International Medical Congress in London in 1881. Here was fought the battle royal, an occasion which those of us who participated will never forget.

Drainage and abundant absorbable dressings lasted longer and are still in use by some surgeons, even in aseptic wounds. They may be accepted as a *sine qua non* in infected wounds. One reason why Mr. Lister for so long a period insisted on drainage and absorbable dressings was his fear that the serous effusion was too abundant to be absorbed or become vitalized. A second and perhaps equally important reason was that he closed his wounds by interrupted sutures and looked on the possibility of an infection traversing the line of the suture. It does not appear to have occurred to him at this early period that sutures could safely be buried even in well-vitalized structures.

AUTHOR'S EARLY USE OF BURIED ANIMAL SUTURES

On Feb. 19, 1871, in consultation with Dr. A. P. Clarke of Cambridge, I operated on a patient, Mrs. M., aged 50, who had suffered for years from hernia. Five days previous she was seized with severe pain in the inguinal region, accompanied by vomiting. Long continued and careful taxis had failed to reduce the hernia, and for twenty-four hours the vomiting had been stercoraceous, and the patient seemed *in extremis*. The hernia tumor was the size of an egg, protruding from the external inguinal ring. A careful dissection exposed the sac, which was closely adherent to the surrounding parts. The constriction was at the internal ring and was divided with some difficulty. The hernial contents were reduced, and the sac, unopened, was returned within the ring. Two stitches of medium-sized catgut were taken directly through the deeper structures about the ring. The wound was dressed antiseptically, and from Dr. Clark's notes, taken at the time, I find that the patient steadily progressed without pain or accident and was convalescent in three weeks. The result was a radical cure of the hernia, although the canal was not closed for this purpose. The opening into the abdomen was so large that we feared the escape of the contents, especially as the patient was afflicted with a severe chronic bronchitis. I only expected the

sutures to hold the parts *in situ* temporarily. Mrs. M. died six years after the operation, and was troubled with the cough during the entire period, but the canal remained firmly closed at her death. She did not wear a truss after the operation.

On March 10, 1871, assisted by Dr. W. W. Wellington of Cambridge, I operated on Mrs. L., aged 45, suffering with strangulated hernia, usually retained by a truss. It was on the left side and direct inguinal in variety. The sac was returned unopened; the canal was closed by three large sized catgut sutures, taken deeply through the pillars of the ring, and the wound carefully dressed antiseptically with Lister's carbolyzed lac-plaster. When examined the following June, the cicatrix was linear, and a firm deposit of new tissue could be felt, marking the site of the buried sutures. I reported these cases at the meeting of the County Medical Society, Oct. 11, 1871, and published⁷ a paper discussing the subject, Nov. 16, 1871. In closing I remarked:

As far as my observation has extended, this is a new use of the carbolyzed catgut ligature and suggests a still wider field of application. No method of operation for the radical cure of hernia appears more feasible, is probably attended with less danger, and at the same time affords a means of closing and strengthening the weakened ring, which is so desirable, and yet, with all the ingenious devices of surgery, is so difficult to obtain.

Although I continued to operate from time to time, as occasion demanded, in cases of strangulated hernia, and in every case closed the ring with buried animal sutures, it was not until Feb. 4, 1878, that I deliberately attempted the radical cure of a reducible hernia. This patient I had some time previously (Dec. 2, 1877) cured of a large, old irreducible omental hernia of the right side, which had become complicated by the descent of a strangulated loop of intestine. In this instance I dissected the sac and carefully closed the ring and structures of the abdominal wall. A truss retained imperfectly a large direct inguinal hernia on the left side, for which Mrs. W. besought cure, although she was 70 years of age. In the operation I was assisted by Dr. A. L. Norris of Cambridge, who cheerfully gave his approval. In this I was the more fortunate, since until that time my advocacy of operative measures for the cure of hernia in non-strangulated cases had been considered unjustifiable.

The above described experiences paved the way for my application of buried sutures in a great variety of wounds. They were, however, based on a long series of experimental studies in animals, in which I was ably assisted by the late surgeon general, Dr. A. P. Holt, and my laboratory assistant, Dr. S. N. Nelson. These researches were from time to time published in extenso.⁸ It was clearly demonstrated that the catgut was first surrounded by leucocytes, invaded by them, and that, *pari passu*, new connective tissue cells in large degree replaced the suture material, leaving a living band of well vitalized structure, which in a measure reinforced the coapted parts. Later these demonstrations and deductions were amply verified by the splendid research work of Ballance and Edwards.

7. A New Use of Carbolyzed Catgut Sutures, Boston Med. and Surg. Jour., viii, 316.

8. Radical Cure of Hernia by the Antiseptic Use of the Carbolyzed Catgut Ligature, Tr. A. M. A., 1878, p. 295; Animal Ligatures. Ann. Anat. and Surg., 1881, 252; The Animal Ligature. New England Med. Month., June 15, 1883, 387; Surgical Advantages of the Buried Animal Suture, THE JOURNAL A. M. A., July 21, 1888, xi, 71; The Animal Suture; Its Place in Surgery, Am. Assn. Obst. and Gynec., 1889.

INFECTION FROM CATGUT SUTURE

Up to this time I had been singularly fortunate in not having a single case of wound infection traceable to the catgut suture material. I had personally prepared it after the formula advised by Mr. Lister.

In the pressure of a large general hospital practice my supply of catgut gave out. I obtained catgut from a reputable English house and at once had a series of wound infections of a most serious character. In three major operations, one patient died from infection and the others made a slow and imperfect recovery. Bacteriologic study showed that this catgut contained staphylococci. The fruitage of this unfortunate experience caused me to determine that catgut was in itself naturally defective as a suture material and not easy of sterilization. I found that the catgut of commerce was manufactured, briefly, as follows:

The small intestine of the sheep is permitted to undergo a process of decomposition until the more resisting connective tissue sheath can be separated as a firm, white fibrous cylinder, not unlike the sausage-skin of the butcher. This connective tissue sheath is necessarily infected by bacteria in considerable variety. It is split longitudinally into different widths, stretched, twisted and dried.

The violin-string of commerce, as every one knows, in its dry state is remarkably strong; and yet there is a yielding of its fiber sufficient to demand repeated increased tension, or tuning, in order to secure the requisite musical tone. A study of the histologic elements of the connective tissue sheath of the intestine in animals makes it perfectly apparent why catgut necessarily falls far short of the ideal material for sutures. The ultimate fibers are disposed in oblique rather than parallel lines, obviously to permit the easy distension of the viscus. Otherwise the intestinal canal could not easily accommodate itself to its contents. The longitudinal splitting of the sheath of the intestine necessarily cuts these fibers at an angle, leaving a resulting product not unlike that produced by the dividing of a very delicate silk gauze on the bias. Any attempt to twist an oblique section of silk gauze into a cord results in a weak and most unsatisfactory product. The difference between the twisted silk fabric and the twisted catgut lies in the fact that the cement substance, collagen, holds the connective tissue fibers in a much closer union. This, however, is subject to an easy absorption of water and gives in the undried ribbon of the intestinal sheath a soft, flat, slippery, elastic product unsuited to any constriction purposes. Immerse catgut for a short period in any watery solution and note its changes. It first becomes swollen, and this is the reason why the catgut suture is threaded through the needle with difficulty. After a long immersion it can be untwisted, leaving as result the more or less softened, flattened band. This is why the knot of a catgut ligature is untrustworthy. The fault is inherent in the material, not in the surgeon. As a crucial experiment, select a beautiful coil of catgut, use it as a fish-line and note the results. Then remember that the buried suture material is immersed in the fluids of the body and must of necessity undergo a process of maceration.

The experience of these many years has shown that although catgut can unquestionably be sterilized, the process is by no means an easy or satisfactory one. The cement substances holding the connective tissue fibers

is necessarily damaged, first in the process of separation of the connective-tissue sheath from the other components of the intestine. This is still further damaged, as well as the fibers themselves, by nearly every process in use for sterilization. Influenced by these studies, I at once instituted an active search for better suture material. I then for the first time discovered the remarkable facts already narrated at some length, and found, to my astonishment, that for a generation animal ligatures, introduced by Dr. Physick, had been extensively used in America, all of which experience had been forgotten and lost. Of the very considerable variety of material used for ligatures it was clearly apparent that the tendons of animals were anatomically the best, since the fibers were parallel and they could be prepared with less injury to the cement substance in the ligation of arteries and had been used for the ligation of the pedicle of ovarian tumors by Dr. Bellenger of South Carolina in 1830 and later by Dr. Eve of Nashville, Tenn.

SEARCH FOR SUITABLE SUTURE MATERIAL

I found nothing suitable in the tissues of domestic animals; although a comparatively good ligature material was obtained from the tendons of the ox, it was rare to find fibers fitted for sutures. I knew that the Indian women of the northwest used tendons in place of thread for the sewing of their skins.

In the tents of the Dakotas I found willing teachers. The fascia lata of the buffalo was used for suture material, and this failing, that taken from the moose. From this source I obtained a fairly satisfactory product. The hind leg of the moose also furnished a fairly good material. The tendons from the crane and ostrich are of ample length. I obtained tendons from the tail of the whale four feet long, and large and strong enough to serve as ropes.

The peculiarity, however, of all these tendons is that the fibers interlace, an extremely wise provision for Nature's use, but not suited to the manufacture of fine thread. Dr. Simmons of South Carolina sent me tendons from the tail of the fox squirrel; and, for the first time, I learned that in this animal the disposition of the psoas muscle is different from that of any other animal I had then examined, in that each fasciculus of the muscle has its own separate tendon extending to the very extremity of the tail. In the squirrel they are extremely beautiful, not much larger than coarse hairs, but only six or seven inches long. My desire now was for larger squirrels. My late friend, Dr. Hunter McGuire of Richmond, furnished me the opossum for dissection. Here I found the same anatomical distribution as in the squirrel, but the tendons were still too short to serve for most suture material, although beautifully fine and even. The books on comparative anatomy were singularly oblivious on the peculiar anatomic distribution of the tendinous structures of the tails of animals, but at last I thought that I had found the key: Since the opossum was a marsupial, it was extremely probable that the construction of the tails of this entire group would be similar.

At this time I had under care a retired Australian merchant, from whom I sought instruction. His playful reply was that he knew that the tails of these animals made excellent soup, but as a personal favor he would have the subject investigated and have a report made me. In due time the answer came in a considerable bundle of tendons from the tail of the wallaby, a species of small

kangaroo. The problem at last seemed settled, and I have never since received finer specimens.

There is a considerable difference in the number, but each tail contains usually from twenty to thirty tendons. The smaller varieties of the animal furnish tendons in sizes of considerable variety, and but few of them too large for use. The anatomic disposition remains the same in the larger species, and specimens from these animals are not seldom three feet in length and strong enough to draw a carriage. Although there are few interlacing fibers in these tendons, and although when split with care they furnish much excellent suture material, they are never quite so even, sound, smooth or strong as whole tendons.

Their method of preservation is of importance. The tendons must be taken from freshly killed animals, kept straight, quickly dried and kept dry in shipment. As most surgeons know, the ultimate fibers of a tendon are parallel, overspacing each other in a uniform manner, are held together by a cement substance and constitute some of the strongest structures of the body. Carefully selected tendon sutures of equal weight are stronger than silver wire. Such strength, however, is of minor consideration, since great tension on sutures is seldom required.

PRESERVATION OF TENDON SUTURES

The processes of preparation of tendon sutures are not difficult. Good tendon is comparatively aseptic. The tendons are soaked in a one to a thousand corrosive sublimate solution until soft. They are then easily cleaned and separated and dried straight on wet, sterile towels. The further preparation consists in immersion in a weak solution of formaldehyd, about one part to two hundred of sterile water. They are then chromicized in the usual manner and dried. The tendons are then permanently put up in boiled linseed oil, to which has been added one-twentieth part of carbolic acid crystals.

It will be noted that this is not an important departure from the method first recommended by Mr. Lister. I have tried nearly every method advocated from time to time, besides many experimental studies of my own, but nothing has proved so satisfactory. When preserved in alcohol, after a time tendon and catgut become brittle. When kept dry the material depreciates in value and after a time becomes untrustworthy; on the contrary, preserved in the carbolized oil, I think the suture material is rather better after some months. I now have specimens of catgut prepared over thirty years ago which are satisfactory and trustworthy.

In regard to the preparation of catgut there is still much discussion, owing, as I think, in large degree to the inherent defects already referred to.

In order to prevent the putrefactive changes in the separation of the connective-tissue sheath of the intestine, the intestine from freshly killed animals has been utilized. The fibrous coat is separated in a comparatively aseptic state. This, of course, when properly done, is of great advantage. The sterilization is also effected before the twisting process takes place. Various antiseptics have been used to be incorporated in the sheath before the twisting, the most valuable of which are the silver salts, especially the iodid, and pyoktanin. It is asserted by the advocates of these processes that there is a manifest advantage from the incorporation of these antiseptics into the suture material to last

during the entire period of their usefulness within the tissues. There can be no doubt that these chemicals exercise a marked inhibitory power on the reproduction of bacteria, but it is safe to assume, without argument, that if no bacteria have been introduced into the wound, either by the suture material or by manipulative processes, there are no bacteria to inhibit, and therefore the use of these chemicals in such wounds is of very doubtful value. On the other hand, I do not believe, judging from my own experience, that they are particularly deleterious agents. Chemicals of any sort introduced into wounds can not of themselves be considered advantageous; yet most surgeons irrigate wounds with the sublimate solutions freely and for years it has been my daily habit to soak my tendon sutures in a warm, one to a thousand bichlorid of mercury solution, for a half hour before using. I have thought this advantageous in freeing the tendons from oil, which in a warm solution soon floats on top, while the softening of the sutures causes them to be more supple, and therefore more easy of application.

SUBCUTANEOUS SUTURES

The history of subcutaneous suturing is less satisfactory. It is now well known that the hair follicles and sweat ducts are the abiding places of bacteria and that the superficial epithelial layers of the cuticle are in a way freed for easy desquamation by the ever-present countless numbers of the *Micrococcus pyogenes albus*. Any of these bacteria drawn into the wound by improper suturing are favorably planted for colonization. The surgeon may very safely suture the deeper structures of an aseptic wound, accurately coapting like tissues. This should, of course, be done by continuous sewing and it must be remembered that undue constriction is to be avoided. One of the important maxims ever to be kept in mind, however, is coaptation and not constriction.

Subcutaneous suturing is more difficult. In the first place, the suture should be sufficiently fine and not chromicized, that its absorption may be assured before the normal process of skin growth brings it to the surface. The suture material itself is not exposed to invading bacteria. The stitches must penetrate only the very deeper layer of skin and must be taken from side to side so that each stitch enters exactly opposite the emergence of the preceding one. In this way by gentle traction the skin edges are brought into even coaptation, the last suture is fixed with a half knot and the needle emerges at some distance from the end of the incision. The wound is carefully dried and sealed with iodoform collodion. The ends of the suture are drawn on, cut short and allowed to retract beneath the skin. The iodoform has a distinct inhibitive power on the development of bacteria of the skin. In this way, wound treatment is reduced to its lowest terms of simplicity and safety. No drainage should ever be permitted in aseptic wounds in healthy structures. To this rule even the amputation of the thigh is no exception. An aseptic wound thus made and sealed must remain aseptic, and primary union will follow.

DISADVANTAGES OF METALLIC SUTURES

I have referred to the early use of wire which was reintroduced to the profession by Drs. Sims, Emmet and others. The work of Dr. Sims in establishing the cure of vesicovaginal fistula will ever remain a monumental contribution to surgery. I do not think that I have ever seen a more dextrous opera-

tor. He may justly be accredited as the founder of gynesc surgery. He attributed a large degree of his success in plastic surgery to the use of silver wire interrupted sutures. Following the teaching of this distinguished author metallic sutures soon became popular. Their superiority over linen or silk in septic wounds, then the rule, is self-evident. Metallic sutures may be buried and remain indefinitely in the tissues. As a rule, however, they are necessarily a source of irritation, being foreign bodies, and sooner or later must be removed.

PROPERTIES OF SILK SUTURES

Silk or linen suture material is easily made aseptic or antiseptic by heat, impregnation with iodid of silver, pyoktanin, etc. During the indefinite past, the instruction had been to wax well the ligature. The beeswax incorporated into the fiber rendered it not only smooth and less irritating, but, as we now know, lessened the liability of the ligature to become filled with bacteria. One of Mr. Lister's early experiments was the immersion of the silk in a hot bath of melted beeswax to which 10 per cent. of carbolic acid had been added. The superfluous wax was removed by repeated drawing of the suture material through a fold of cloth.

Silk as a buried suture has the advantage of being easily sterilized, and its strength permits the use of very fine thread, it being important to minimize the amount of unabsorbable material buried in the tissues. Silk in itself is an animal product and may be absorbed, but the absorption is such a decided exception that silk may be classed as an unabsorbable material. The evidence is so conclusive as not to admit of argument that silk ligatures, even when small, interrupted and cut close to the knot, are a frequent source of discomfort and suffering.

I have in my possession three loops of silk ligature with the following exceptional history: About three months prior to my operation the patient had had the ovaries and tubes removed by one of the leading New York surgeons. Primary union followed and she was discharged convalescent four weeks later. After a time she was seized with the most frightful torture from vesical irritation. There was an almost constant desire to urinate, never followed by relief. She had been kept almost constantly under the influence of morphin, although still in a state of extreme suffering. Under ether I dilated the urethra and removed three calculi the size of small cherries. Two were free in the bladder, but a third was still attached to the posterior wall of the bladder by a portion of the ligature. Each contained as the nucleus the interrupted silk suture unchanged, with the knot still remaining firm.

ADVANTAGES OF TENDON SUTURES

Although there are surgeons who still use silk as a buried suture, the number is far less than formerly. One of the more prominent New York hospital surgeons told me only recently that nearly all the New York surgeons used kangaroo tendon sutures almost exclusively.

METHOD OF SUTURING

If absorbable sutures are to be used, how may they best be applied? Coaptation and fixation, at rest, of like structures with as little force applied as possible, is the object sought. More suture material than is required for these purposes is detrimental. The suture must be applied with a minimum of devitalization of the tissues which are coapted. The interrupted suture

is faulty in that it holds at only the single point of application; and in order to make complete coaptation in large wounds, undue compression, often to the devitalization of the part constricted, must be used. Each stitch necessitates a knot.

The interrupted suture is the legacy of the fathers, and used by them distinctly with the purpose of removal. In order to relieve the tension of the exudation of fluids, a stitch was cut from time to time as thought desirable.

If the wound remains aseptic, primary union will supervene, and the stitches taken through the skin for the purpose of removal have no advantage in being single. Thus taken, the interrupted stitches coaptate far less evenly and securely the included tissues, and require much more time to apply them than do continuous stitches. If the seamstress or the tailor made our clothes in this manner, we should wonder at their bungling methods. The principle is precisely the same with the surgeon; and, even if he has to serve an apprenticeship to the tailor, he should certainly not be less dextrous, since Nature's most precious coat should be most artistically repaired.

Like structures, as far as possible, should be coapted; fascia to fascia, muscle to muscle. Fine continuous running sutures, taken rapidly, accomplish this purpose in a manner so as not to leave pockets for the accumulation of fluids. The accumulations as well as larger tendons applied in many layers, we know, if aseptic, will usually be cared for by Nature's processes, but it is a part of our art to minimize the burden, instead of making the effort to determine how much she can accomplish in this direction. The over-and-over suture, glovers' stitch, is undoubtedly the one in more common use, but it does not serve the purpose in the coaptation of wound structures nearly as well as the parallel stitch, in which the needle is inserted deep within the tissues parallel to the long axis of the wound, and each succeeding stitch is made by introducing the needle exactly opposite the emergence of the preceding one. In this way, on tension, coaptation is evenly secured, and the suture material crosses the incision at right angles and by this means the suture is completely buried in healthy, closely coaptated structures. Sometimes, for example, in the reconstruction of the inguinal canal, the closure of the peritoneum and the fascia, there is a decided advantage in sewing a double line of sutures, just as the shoemaker sews leather, the needle with eye near the point serving as a shuttle to carry the suture. It must, however, be remembered that much force is inadvisable, since coaptation, and not constriction, is the purpose.

In sewing, the needle is of importance as well as the suture, and the profession is greatly indebted to Hagadorn for his valuable addition to our armamentarium in this direction. The medium sizes of fully curved needles serve best, since they can usually be used by the fingers without the aid of forceps.

The continuous suture requires but a single knot, and is less liable to cause undue constriction than the interrupted suture, since a compensation occurs, equalizing the force applied to the entire suture. This I consider of the first importance, since under the influence of earlier teaching, most surgeons still use too much force. Injury and devitalization of the tissues is the consequence. The extraordinary strength of tendon is in a measure a fault, since its unyielding character admits easily of undue force.

The frequent inquiry is made for larger tendon, "since I must have it very strong." Some time ago one of Europe's most distinguished surgeons operated in my clinic. He would have only braided silk, and in its application broke all his sutures finer than No. 8. Such force must necessarily cause necrosis of all the enclosed structures.

All aseptic wounds closed with buried aseptic tendon sutures will remain aseptic and in well vitalized structures will be followed by primary union. There is no danger of subsequent infection, no expensive and troublesome dressings are required; the anxious forebodings of the surgeon "lest something go wrong with his wound" is avoided; no sutures are to be removed, relieving greatly the dread and anxiety of the patient; safety is greatly enhanced and the period of convalescence is shortened. When the work has been done with care the resultant cicatrix is scarcely visible, a matter of much importance in some portions of the body. Operations hitherto impossible have been rendered feasible by the use of buried absorbable sutures; for example, the reconstruction of the pelvic structures, the closing of rents in the peritoneum, etc. The reconstruction of the obliquity of the inguinal canal for the cure of hernia in the male has become an almost everyday occurrence. It was for this very purpose that I first used the buried animal suture in 1870, and am now in my five hundredth series of cases with over 90 per cent. of resultant cures. My operation under various names is now practiced in every part of the civilized world, for the cure of the female vesicovaginal and rectovaginal fistula. The reformed structures may be greatly strengthened by the rejoining of the sundered tissues by means of lines of buried sutures, as contrasted with a single layer of interrupted sutures, for example, the closure of the abdominal wall in laparotomy. Here, in the closure of the wound by a single line of interrupted sutures, about 10 per cent. of the cases result in hernia at the line of the incision. Not seldom an abdominal bandage is ordered to be worn for a year. This I consider worse than useless. When closed in layers, the composite structures are rejoined, and in primary union hernia should be altogether avoided. In over two thousand laparotomies of this character I have had but a single subsequent hernia. Indeed, this is but to be expected, since like structures are joined, and the suture itself is replaced by a living band of connective tissue. To-day the aim of the surgeon is to reconstruct and restore, as far as possible, to the normal pattern, all the healthy tissues remaining for manipulation. To this end a tumor is removed, and the parts completely closed, if possible. Although our mission is necessarily iconoclastic, the service should be rendered with such gentleness of measures that Nature accepts it as her best ally, and a double blessing follows the ministrations of the surgeon, not alone in the averting of the threatened danger, but also in the accomplishment of the same with the minimum of pain and suffering, and the maximum of safety. I consider the buried animal suture my best contribution to surgery.

With all the emphasis of an earnest conviction, I commend to every aseptic surgeon familiarization with the methods of wound closure by means of buried absorbable sutures, preferably tendon, and predict not only that they will receive early general adoption, but that, in importance, they will hold the first place in the technic of modern aseptic wound treatment.

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ABSTRACT OF DISCUSSION

DR. HARVEY P. JACK, Canisteo, N. Y.: Kocher, in his latest work, expresses wonder that so many of us continue to use absorbable sutures; he reports 100 cases of aseptic breaking-down of wounds. Catgut, chromicized or formalized, has been the only suture material that I have used since I began the practice of surgery. I will report one more case of aseptic breaking-down of the wound somewhat in detail, that you may be able to give some solution of the cause of breaking-down. The case was one of hysteromyomectomy; the time consumed was only thirty-five to forty-five minutes, and the wound was closed in layers by means of No. 2 chromic catgut, made by one of the best manufacturing houses in the United States. The patient did well for two weeks with normal temperature; then I was summoned to the hospital by the statement that the patient had vomited up her intestines. The wound had broken open and a large part of the small intestines was lying on the abdominal wall. I introduced three layers of sutures, using catgut for the buried sutures and re-enforcing that with silkworm gut. The woman made a perfect recovery and left the hospital three weeks from the time of entrance. The patient was pronouncedly gouty. Whether that had anything to do with the rupture of the catgut I do not know. She was also a neurasthenic, although she had been carefully prepared for the operation and re-enforced in every way. It was, however, with much difficulty that she was properly nourished. But the catgut in the wound was absorbed almost entirely at the end of two weeks. Since that experience I have closed the peritoneum with silk. The suture material was thirty-day catgut.

DR. D. TOD GILLIAM, Columbus: For a good many years I have used absorbable sutures in my abdominal work, and up to six months ago I have used the method of closing the abdominal wound by overlapping the fascia as we do in the hernial cases. I used the chromicized gut and found that I was having a great many cases in which the wound would open—not down to the abdominal cavity, but the outer layers would open. There was no suppuration, but a secretion of serum, and it was due undoubtedly to the irritation of the unabsorbed catgut. I am sorry to say that by reason of this I have been obliged to come back to the old method of the silkworm suture, using the method known as the “figure-of-eight suture.” It is not satisfactory to me in all respects, but I have had so much evil result from the chromicized gut that I have been obliged to return to this antique method.

DR. A. ERNEST GALLANT, New York: My experience shows that difficulty in the abdominal wound has often been due to my having tied a double knot in the suture material. While absorption of the suture takes place the knot remains as an irritant because of its consistency.

DR. HENRY O. MARCY, Boston: One who will carefully read the paper *in extenso* will find that the criticisms made and many others have been answered. In the case in which the No. 2 thirty-day catgut was used and the tissues broke down, I think that there was something wrong with the repair process and not with the catgut. You all know that two weeks will give carefully coapted structures time to unite. It is a good plan, with a long abdominal wall, to restrain muscular action. I put on a strip or two of adhesive plaster to hold the abdominal wall at rest. Well-selected kangaroo tendon will hold much longer than catgut. It is an important matter to have few knots and to put coapted structures at rest without there being any undue constriction—in other words, to immobilize the wound.

The Economic Cost of Tuberculosis.—The total cost in the United States exceeds \$1,100,000,000 per annum. Of this cost about two-fifths, or over \$440,000,000 per annum, falls on others than the consumptive. An effort to reduce the mortality by one-fourth would be worth, if necessary, an investment of \$5,500,000,000. The erection of isolation hospitals for incurables is probably the most profitable method at present of reducing the cost of tuberculosis.—Prof. Irving Fisher.

Clinical Notes

DIPHTHERITIC CONJUNCTIVITIS

MARIANA BERTOLA, M.D.

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SAN FRANCISCO

This paper is not written from the standpoint of the specialist but from that of the general practitioner. It does not present anything new for consideration, but it calls attention to a condition which is more frequent than is commonly supposed.

FREQUENCY

Jacobi of New York says that about the year 1850 diphtheritic conjunctivitis was frequent and destructive. DeSchweinitz declared it rare in America and England and very prevalent in France and Germany. Since that period the number of cases reported has been less. In pre-antitoxin days Graefe reported three cases and three deaths; Gilbert, four; Widmark, one.

In 1904 Kooker reported eighty-one cases of diphtheria, in forty-seven of which diphtheritic conjunctivitis was present. In 1904 Juler also reported one case. In 1906-7 Bruns, having a splendid opportunity in the south, reported thirty-six cases. The *British Medical Journal*, the *Lancet*, and THE JOURNAL report no cases for 1906.

McCollom declares that the conjunctiva is rarely attacked by the Klebs-Loeffler bacillus. Of our local men, Dr. A. Barkan reports a small number of cases secondary to nasal diphtheria, also a number of cases of pseudo-diphtheritic conjunctivitis. Dr. W. B. Lewitt reports one “in which there was a distinct membrane at the inner angle of the eyes.”

CLASS: PRIMARY OR SECONDARY

The majority of the few cases reported have been secondary, and most commonly secondary to nasal diphtheria.

Stephenson makes note of a number of cases secondary to “bronchial diphtheria,” and to “running ears.” Barkan writes of a number of “pseudodiphtheritic” cases “in the wake of blennorrhoea in the adult and in the new-born.

Lewitt's case “was in connection with a most malignant case in which the larynx, pharynx and nasal cavities were involved. In the mouth the membrane covered a portion of the hard palate.”

The secondary cases are from autoinoculation from discharges from other infected areas.

In the *Lancet* of Jan. 4, 1908, Slater reports a case of a girl who was treated for some eye inflammation; a week or two later several white patches were found on the vulva and spread elsewhere on the skin. Anti-syphilitic treatment was tried for two years. Then after inoculation of agar and blood serum tubes and experiments on guinea-pigs, the Klebs-Loeffler bacillus was found. Diphtheria antitoxin was given and immediate improvement followed. Slater believes that the patient's eyes were the primary seat of infection.

Primary cases in attendants on patients in tonsillar cases have been reported, the discharge having been coughed by the patient into the eyes of the attendant.

SYMPTOMS

The period of incubation is from twenty-four hours to four days. McCollom says that diphtheria differs from