

become practically obliterated up to the first branches of the collateral circulation.

The thrombus is a mere passive structure, and takes no part in the growth, but is protective and affords an excellent medium for the germination of the new tissue.

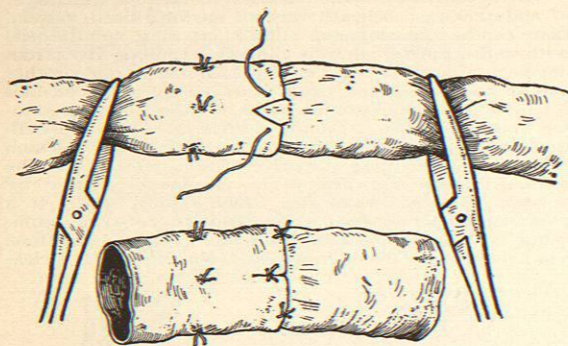


FIG. 324.—Method of Inserting External Sutures. (After Murphy.)

Its upper portion is not penetrated by the new growth, but rests upon it and forms a sort of protecting scab. It is deposited gradually, and has a stratified appearance. Its size appears to be dependent upon the amount of injury done to the vessel and the resulting inflammation. If the intima or the elastic lamina has been ruptured in handling the vessel, as can frequently be demonstrated by the microscope, some distance from the point of ligature, clots will form at these points, and the thrombus will thus become elongated. Occasionally, the apex is formed of white corpuscles only, and may be free or lightly attached to the wall by a cell growth from the intima. The distal thrombus is shorter than the proximal, and much narrower, so that there is but little difficulty in distinguishing them from each other.

It was at one time the custom to place a double ligature upon large vessels, in place of a single ligature, and to divide the vessel between them. This procedure was advocated by Jones, who says: "In the single ligature, although the knot is soon covered up and protected by an effusion of lymph, it is placed in the centre of a portion detached from the surrounding cellular membrane, and the process of repair cannot go on so well, as the nutritive vessels are cut off. In the double ligature, the knots are placed where the connection of the vessel with the surrounding tissues is complete."

This theory has recently been revived by Walsham, who considers the separation of the artery from its sheath as important a factor in influencing the result as tightness of the ligature or division of the coats, inasmuch as the vitality of the artery depends in a great measure, he thinks, upon the blood supply received from the sheath. But Holmes objects to this method on account of the free dissection and exposure of adjacent vessels rendered necessary: if the knot "will keep its hold on the vessel until the seat of the ligature is buried in a mass of new fibroid material, secondary hemorrhage, if not impossible, is, at least, very improbable." The method, he says, has passed out of use when secondary hemorrhage was common, to be brought back when it is rare.

The supposed danger to the vessel wall, incurred in applying the single ligature, is based upon anatomical rather than upon pathological conditions, and, in the light of present knowledge, is a theoretical rather than a practical objection.

Murphy has recently experimented with sutures of veins and arteries. In suturing lateral openings of arteries the sutures should enter only the adventitia and media, the intima being avoided to prevent endarteritis. The sutures should be inserted every one-sixteenth to one-twentieth of an inch. Hemorrhage from needle punctures

may be controlled by gentle pressure. If necessary to resect a portion of the artery not more than three-fourths of an inch should be removed.

Murphy's method of invaginating the ends of the vessel is shown in Figs. 324 and 325. Twisted silk is used for sutures and eight-inch Billroth compression forceps with broad blades and catch are employed to control the ends of the vessel. The blades are covered with rubber tubing to protect the vessel. In order to facilitate the invagination a small incision is made parallel to the long axis of the vessel extending for a distance of from one-fourth to one-third inch. The arterial blood pressure tends to press the walls closer and thus prevent hemorrhage.

Murphy has successfully treated the femoral artery in this way in a man twenty-nine years of age. The artery was perforated by a bullet, which also caused a linear wound of the vein which was sutured.

LIGATURES.—It was chiefly due to Jones' investigations that the modern single thread found at one time almost universal adoption. Cutting short both ends of the knot was adopted as long ago as 1798 by an American naval surgeon. The disadvantages of a silk or hempen ligature were supposed to be due to its non-absorption and the liability to produce suppuration, but the ordinary silk or hempen ligature, if cut short, will eventually be absorbed.

The introduction of the animal ligature is generally ascribed to Physick, whose ligatures were made of chamois leather rolled on a slab, to render them hard and round. Sir Astley Cooper tried them, and they were used in this country on all the large vessels by Jamieson, of Washington, who advised using the buckskin soft and a little broader than the ordinary thickness of the skin.

The most common form is the catgut ligature. It is prepared from the small intestine of the sheep by scraping away the muscular and mucous coats, all that remains being the submucous cellular coat and a narrow strip of peritoneum. The translucent membranous tube which remains can be twisted entire for the coarser forms of catgut, and is then dried. For the finer kinds,

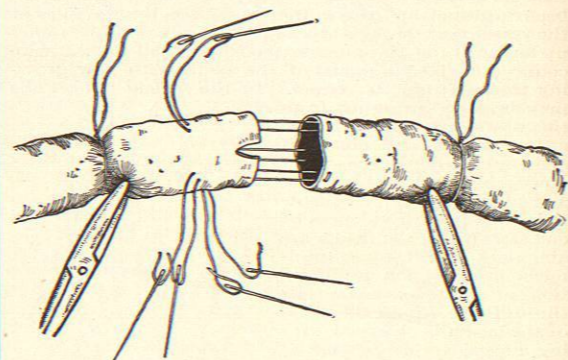


FIG. 325.—Method of Inserting Sutures to Produce Invagination. (After Murphy.)

the submucous coat is split by means of razor blades, more or less numerous, according to the degree of splitting required, and connected with a conical piece of wood which is pushed along the tube. If it has not been properly prepared, the substance of the catgut becomes converted in the course of a very few days after the application of the ligature into a soft, pulsatious mass, which, when we examine it by a microscope, we find to consist of remains of the old cellular tissue of the submucous coat, the interstices among the fibres being filled with cells of new formation. The catgut tissue is infiltrated with young growing cells, and it is obvious that it is this infiltration which is the cause of

the softening; but, on the other hand, if the catgut is properly prepared, instead of being infiltrated by the cells of new formation it is only superficially eroded. Until nearly a fortnight has elapsed, erosion does not begin. It then proceeds gradually, and, therefore, the

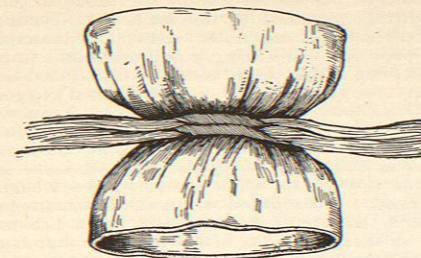


FIG. 326.—Ballance and Edmunds' "Stay Knot": Floss Silk Ligature; First Stage.

thicker the catgut the longer is the time required for its complete removal. We may fairly consider that from a fortnight to three weeks is long enough for the persistence of a ligature upon an artery in its continuity. If over-prepared—that is, rendered too hard by the chromic acid—it may be discharged whole, as in the case of the hempen ligature quoted. Many of the failures with catgut can be referred to improper modes of preparation; and although the danger of obtaining a material that is too readily dissolved is not so great since the introduction of the chromicized gut, the necessity of being so dependent upon the care of the manufacturer constitutes a certain objection to its use.

Other forms of ligature are those prepared from the kangaroo and whale tendons.

Barwell has proposed, in the treatment of aneurism, the use of the ox-aorta ligature, which can be applied so as not to divide the internal coats, and need not ulcerate through the artery. He thinks it becomes organized, having seen remains inseparably mixed with the surrounding tissues fifteen months after it had been applied. In other cases it is absorbed. It is prepared by cutting spiral strips from the aorta. A weight is attached to the end of each flat band thus produced, and the band is hung up and dried. Just before use it may be moistened in a solution of carbolic acid.

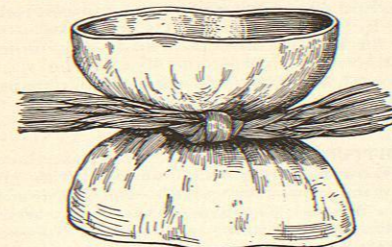


FIG. 327.—Ballance and Edmunds' "Stay Knot" Completed.

Dent reports a case of the application of the tendon ligature to the carotid and subclavian arteries followed by death at the end of ten days. In an examination of the carotid, the knot of the ligature was found in close contact with the artery, encysted in a small cavity in the effused lymph. The knot was almost gelatinous in appearance. Transverse sections showed that the external coat of the artery "was not ulcerated," and this condition is considered due to the slight swelling and softening which such a ligature undergoes. New blood-vessels were found developed in those parts of the tendon which lay close to the artery; that is, rows of spindle-shaped cells, with spaces between, were seen branching in the

tendon tissue, and blood-vessels were seen passing into both the artery and the tendon; the tendon was also infiltrated in other portions with granulation cells; some of the adjacent muscular coat was being attacked and eaten away. This question of the organization of the ligature was first raised by Lister, who now explains that he does not mean that the catgut comes to life again, but "new tissue forms at the expense of the old, that the old tissue is absorbed by the new, and that as the old is absorbed new is put down in its place." Evidently he is here describing the formation of the provisional tissue, or external callus, and the gradual absorption of the ligature. The observations of Dent may be interpreted in the same sense, the granulation tissue pushing its way into the interstices of the knot preparatory to "eating it away," as it already has done portions of the muscular coat. In Barwell's case the preservation of a distinct band, fifteen months after ligature, may be accounted for by supposing that the ligature had not been wholly absorbed. Much misconception has arisen from an improper preparation of such specimens. In order properly to appreciate existing conditions, the vessel should be removed with the surrounding inflammatory tissue attached to it, should then be placed in some hardening fluid for a few days, and, finally, a longitudinal section, with a sharp razor, should divide it into equal halves.

Ballance and Edmunds call attention to the danger of failure to close the lumen of an artery ligatured in continuity by the ordinary single ligature. This is due to the loosening of the first half of the knot while the second half is being tied. They recommend the "stay knot." Floss silk is employed and two ligatures are placed close to each other and the first half of each knot is tied in the usual way. In the second half of the knot the two ends on each side are treated as one and the second hitch is tied as if completing an ordinary reef knot. The knot should not, according to these authors, be tied so tight as to rupture the inner walls, but only so as to place them accurately in apposition. The danger of hemorrhage or of aneurismal dilatation, they claim, is thus avoided. (See Figs. 326, 327, and 328).

In large arteries ligatured in continuity a stout braided silk ligature will hold the wall of the vessel firmly in contact after the first half of the knot has been tied for a sufficient length of time to enable the surgeon to complete the knot, and is, owing to its simplicity, to be preferred to the "stay knot."

Metallic ligatures have not been favorably received, though satisfactory results have been reported, a number of such ligatures not interfering with union by first intention. The difficulty of regulating the tension of the vessel, appear to be the chief objections to them for ligature in the continuity. To smaller vessels they are not so easily applied as are pliable ligatures.

Torsion was not unknown to the ancients, as has already been shown, and was employed by certain surgeons in the Middle Ages; but in more modern times, surgeons were not familiar with it until it was brought to the notice of French surgeons by certain statements of a visitor from Germany. Both Velpeau and Amussat apparently claimed the credit of introducing it, the former in consequence of his experience, when a student with a veterinary surgeon, in the twisting of the pedicle in spaying and castration, and both as the result of their observations on the immunity from hemorrhage in lacerated arteries. The method employed by Velpeau is thus



FIG. 328.—Common Carotid of Horse Fourteen Days After Ligature; Approximate of vessel walls without rupture, by two square knots. (Ballance and Edmunds.)

described: "After having seized the vessel by its extremity, I separate it from the surrounding tissue, and grasp it, at its deepest point in the wound, with another forceps, to hold it firmly while it is turned on its axis, three to eight times, by the first pair of forceps." He appears to have employed the method in several amputations. Its supposed advantage was the avoidance of a foreign body in the wound. He recognized the fact that animal ligatures would be equally good for this purpose, and also the disadvantage of torsion in diseased vessels, and that small vessels were not easily isolated. It was, perhaps, for these reasons that, although tried thoroughly by some of the leading surgeons in France and Germany, it fell into disuse until revived by Bryant, in England. The effect of torsion, according to the latter, is a twisting of the elastic fibres of the adventitia beyond the end of the vessel, and a retraction and incurvation of the middle and inner coats; the twist in the outer coat is permanent and cannot be unfolded by any legitimate force; the middle and inner coats are retracted in the direction opposed to the blood stream, approximated and overlapped. They sometimes assume a nipple-shaped projection, at other times a valvular form, being not unlike the semilunar valves of the heart, and closing as perfectly; in some cases, again, they appear to split; in all, the coagulation of the blood is favored. The safety from hemorrhage, according to Bryant, rests upon the twist of the external, the retraction of the internal coats, and the coagulation down to the first branch, while, in acupressure, the permanent safety depends upon the last alone, temporary protection being afforded by the needle.

Kocher found numerous and irregular lacerations of the inner coats over a considerable distance of the wall, and independent of one another, while in ligature the ruptures were circular and only close to the point of ligation. In unlimited torsion there is considerable narrowing of the lumen. Owing to these peculiarities, it has the advantage of favoring a rapid coagulation.

The effect of the limiting forceps in bruising the inner wall of the vessel, and thus favoring both coagulation and repair at the bruised spot, is noticed by Shakespeare, who recommends a similar bruising in ligature (the "modified ligature"). The process of healing is, according to the latter observer, the same in its essentials as that which occurs after ligation.

ACUPRESSURE.—The introduction of this method of hæmostasis is to be accredited to Sir James Simpson (unless an obscure passage in John de Vigo's writings be interpreted otherwise than as a description of the ordinary ligature). He saw in the ligature a foreign body in the wound which cut through the two coats at the time of its application, and ate through the outer coat by a process of ulceration, mortification, and gangrene. Variations in the shape or material of the ligature did not overcome these disadvantages. It was for this reason principally that amputation stumps healed with so much greater difficulty than wounds in the operation for vesicovaginal fistula, although the latter were constantly bathed in leucorrhœal discharges and urine. The application of the ligature isolated a portion of the end of the vessel, which remained in the wound as a piece of dead flesh until it came away with the ligature. The needle, on the other hand, did no injury to the vessel and caused no irritation, its use being based upon "the great pathological law of the tolerance of living tissues for the contact of metallic bodies embedded in their substance." Bryant showed, however, that the ligatured portion did not slough, but became adherent and vascularized. Even though the vitality of such a fragment be completely destroyed, it need not become a slough unless another element, that of decomposition, be introduced, and may, therefore, be surrounded by healthy granulating tissue and become disintegrated and absorbed by a process already described.

Although English surgeons supposed that no injury was done to the vessel by the needle—Hewsen expressly states that no laceration of the internal coat takes place, and Shakespeare does not mention any alteration of the

tunics—Kocher and other German writers have demonstrated longitudinal slits in the intima, but not so extensive as those occurring in torsion. The vessel is thrown into longitudinal folds, which become sufficiently firmly glued together to retain this shape long enough, after the removal of the needle, for the thrombus to form and become firmly attached to the walls. A specimen examined by Kocher at the end of twenty-two hours showed no thrombus, the walls being compressed and somewhat thickened, but a fine probe could be introduced between them. At thirty-six hours a well-formed, egg shaped thrombus is represented by Shakespeare. A drawing by Kocher shows a specimen fourteen days old, when the walls have already separated from each other, and the thrombus is short and wide, having a concave surface on the side toward the lumen, and a convex surface at the other end. The relation which the thrombus bears to the vessel is that of a cork to a bottle, beyond the neck of which it does not project. It is probable that the apex had been detached. Hewsen also mentions that the thrombus is confined to the compressed spot. The final cicatrix has a shape similar to that described as following ligation, and is developed by a similar process of repair. In acutorsion, the lumen of the vessel is narrowed for some distance from its extremity.

In acupressure, in the continuity, the proximal and peripheral ends of the thrombus are continuous, as are also the walls of the vessel, which at first are thickened by a connective-tissue growth; the subsequent changes differ in no way from those already described.

Ogston has tested mechanically the comparative strength of arteries secured by ligation, acupressure, and torsion, by subjecting them to the pressure of a column of mercury. It was found that a column one hundred and fourteen inches in height was insufficient to rupture the ligatured artery. Twisted vessels unfolded at an average height of thirteen inches (or a pressure of 6.5 pounds to the square inch). Estimating the internal blood pressure at from two to eight pounds to the square inch, he concludes that it would appear likely that vessels secured by torsion are very liable to secondary hemorrhage, especially when the heart, recovering from the immediate shock of an operation, begins to beat more forcibly. In acupressure, the column of mercury showed an average height of 23.5 inches. It would, therefore, seem a more reliable method, he says, than torsion, and less reliable than ligation. According to Shakespeare, the healing process is slower both in acupressure and torsion than in ligation.

A procedure somewhat similar to acupressure has been described by Pollock; it consists in substituting a silver wire for the ligature, the ends being brought out through the skin covering the lips of the wound and twisted together. They are allowed to remain, on an average, five and a half days, and the results of this procedure have proved satisfactory. *J. Collins Warren.*

ARTHRITIS DEFORMANS.—(Synonyms: Rheumatoid arthritis [Garrod]; chronic rheumatic arthritis [Adams]; nodosity of the joints [Haygarth]; osteoarthritis; French, *rhumatisme noueux*; German, *rheumatische Arthritis*.)

DEFINITION.—A chronic, progressive disease of the joints, affecting chiefly the articular cartilages, bones, and synovial membranes, and producing loss of function and great deformity.

HISTORY.—Arthritis deformans is a disease of great antiquity. The chiragra of Horace and other early writers was in all probability deforming arthritis of the fingers. Celsus refers to it, and Aretæus¹ describes the appearance of nodules (*πῶροι*) on the joints which fairly correspond to those seen in this disease. All doubt that might yet remain as to the existence of the disease in the most ancient times has been removed, however, by the finding of bones bearing the characteristic lesions in the ruins of Pompeii,² in Egypt,³ Pomerania, and elsewhere.

One of the earliest distinctive references to the disease in the older literature is that of Sydenham,⁴ who clearly

described the clinical manifestations, but attributed them to rheumatism. Musgrave,⁵ Haller,⁶ de Sauvages, and others describe more or less definitely one or other form of the disease. Landré Beauvais,⁷ in 1800, was the first to investigate its pathological lesions, the destruction of cartilage, and the new formation of bone; but, although he described these as belonging to a definite disease which he designated "Goutte asthénique primitive," it can hardly be claimed that he clearly differentiated them from the morbid changes that result from gout and other affections of the joints.

It remained for Heberden,⁸ in 1804, to recognize characteristics which, he suggested, should distinguish the disease from both true gout and true rheumatism. He was at the same time the first to describe the peculiar nodes which sometimes form upon the terminal joints of the fingers and which are still known as Heberden's nodosities. In the following year Haygarth⁹ published a monograph on "Nodosities of the Joints," based upon his clinical experience in thirty-three cases, all women, which early convinced him that there is a "painful and troublesome disease of the joints, of a peculiar nature, and clearly distinguishable from all others by symptoms manifestly different from the gout, and from both acute and chronic rheumatism."

The views expressed by Heberden and Haygarth were evidently but partially accepted at the time, for several authors who followed them failed to differentiate this form of arthritis from gout and rheumatism. Comparatively little was written on the subject, however, until the works of Brodie¹⁰ and Adams¹¹ and the magazine article of Robert Smith were published.¹² These authors accepted the doctrine of the entity of the disease and did much to elucidate its pathological anatomy. To Adams belongs the credit also of having demonstrated that the so-called morbus coxæ senilis of men is pathologically the same affection as the deforming arthritis of the small joints more frequently seen in women. The recognition of the individual nosology of the disease was for a long time checked, in France at least, by the graduation theses of Charcot¹³ and Trastour in 1853. They maintained that it was merely a form of chronic rheumatism, and the opinion was accepted by nearly all French writers until quite recently.

The morbid anatomy, first studied, as we have seen, by Landré Beauvais, was further elucidated in the writings of Cruveilhier,¹⁴ Aston Key,¹⁵ Lobstein,¹⁶ Broca,¹⁷ and others. Fuller¹⁸ and Garrod¹⁹ made valuable contributions to the literature of the affection, and so aided materially in establishing both its pathological and its clinical identity. Garrod went so far as to demonstrate that the presence of an excess of uric acid in the blood, a feature of gout, was not to be detected. Rokitsansky, Förster, Virchow, and Volkmann should also be named in the list of those who investigated its morbid anatomy.

J. K. Mitchell,²⁰ in 1831 and 1833, suggested the nervous origin of rheumatic diseases. He was followed many years later by Senator, Ord, and other authorities, until this has become the most generally accepted theory with reference to deformative arthritis. The name arthritis deformans was introduced by Virchow.

ETIOLOGY.—The idea that arthritis deformans is in any way related to either rheumatism or gout is no longer tenable. The disease may occur, however, in persons whose family histories show the taint of gout or rheumatism or in those more or less subject to either of these affections.

It may occur at any period of life, but the frequency of its onset is increasingly greater from thirty-five to fifty-five, rapidly declining after the latter period. It is much more frequent in women than in men, commencing in most cases during or after the menopause and somewhat oftener in those who have been sterile. Occurring earlier in life, it sometimes follows rapid child-bearing. Uterine disease was a prominent feature in the etiology of 26 of the 33 cases reported by Ord.²¹

Heredit plays at best a doubtful part in the etiology. As A. E. Garrod²² intimates, statistics regarding the

family history are of little value except in those rare instances in which several generations or their recorded histories have come under the observation of one physician, so great is the confusion in the minds of the laity with reference to gout, rheumatism, and arthritis deformans. His statistics of five hundred cases from private practice, he concludes, "lend countenance to the idea which was formerly very prevalent that there exists an arthritic diathesis a predisposition to arthritic disease, upon which gout, rheumatism, or arthritis deformans is apt to be developed." The daughters of gouty fathers are supposed by some authors to be especially predisposed.

Exposure to cold and wet is believed to have less influence in the induction of arthritis deformans than it has in rheumatism. It nevertheless appears to have had an influence in the development of some cases and undoubtedly may increase the suffering; but temporary exposure is probably of much less consequence than is residence in damp quarters. Bad hygienic surroundings, insufficient or improper food, and exposure are given as important factors in producing the disease in children.

Mental and nervous depression, worry and care are recognized as exciting causes and are capable of producing exacerbations. The exhaustion of nerve centres by sexual indulgence and the leading of a dissolute life have been named by Weber²³ as potent factors in some cases. Gonorrhœa and other diseases of the generative organs have been repeatedly mentioned in this connection, although their occurrence in the history of many cases cannot be regarded as of any real significance. The disease is somewhat more frequent in the poor, especially in those who suffer from malnutrition and anæmia. Hadden²⁴ attributes it in part to too exclusive use of amylaceous and saccharine food.

Tuberculous history or infection has been frequently referred to, but it must be admitted that tuberculosis usually develops in early life and carries off its victim before he reaches the age of greatest liability to this affection. It is also difficult to estimate the etiological importance of a disease so prevalent. Influenza and other acute infections seem at times to exert an unmistakable influence on the induction of the disease.

Some authors look upon the most chronic form of monarthritic deformans occurring in the hip (morbus coxæ senilis), especially in the very aged, as merely a result of senile change in the joint.

There are two principal theories in regard to the etiology: First, that the disease is of nervous origin, and, second, that it is a chronic infection. The former of these theories, suggested by Mitchell, is well supported by clinical facts, chief among which are: (1) the symmetrical distribution of the joint lesions; (2) the similarity of these lesions to those occurring in locomotor ataxia, syringomyelia, and other affections of the spinal cord; (3) the frequent occurrence, in the course of the disease, of nutritive changes (dystrophies) of the skin, nails, muscles, and bones; and (4) the evident importance of shock, worry, grief, and mental exhaustion in the etiology of some cases.

Unfortunately sufficient post-mortem investigations have not been made to determine the nature of the changes which are supposed to exist in the nervous system. Falli²⁵ reports two autopsies on typical cases in which he found atrophy of the anterior horns of the spinal cord, and also, in one of the cases, degenerative changes. Neuritis has been demonstrated in several cases, but, as Osler²⁶ remarks, it is doubtful whether the change is primary or secondary. Ord compares the disproportionate atrophy of muscles to that of progressive muscular atrophy, and infers from their similarity that the disease may be due to lesions in the trophic centres of the cord or to peripheral irritation. Blake²⁷ attributes the nerve changes to the absorption of various toxic substances from within or from without, and, in the same way, Bouchard²⁸ attributes Heberden's nodosities to that form of auto-intoxication which is associated with dilatation of the stomach.

The theory of microbic origin has attracted much atten-