

The conveyance of the salt to any part of the country would be effected with the utmost facility.

Some attention to the dissecting instruments will be necessary to keep them from being corroded.

Whether the common muriate of soda would avail, I cannot determine; but, as the solid salt is more effective in the preservation of meat, it is reasonable to infer its superiority for anatomical purposes. The operation by which it is distinguished in its preparation from the common salt deprives it totally of the muriate of magnesia, which, I am informed, promotes putrefaction.

It must be understood, that the plan is chiefly recommended for those to whom economy is important; at the same time, it seems applicable to some purposes for which the volatility of spirit renders it unfit.

It did not concur with my object, to sanction these experiments with the approbation of distinguished characters, yet, independently of the personal honour I feel in being permitted to introduce the name of Sir Joseph Banks, the permission derives importance, from the influence which he has long illustriously diffused by a most liberal cultivation of the arts and sciences.

At the request of Mr. London, and by a previous arrangement with Sir Joseph, I laid before, and left with him, the specimen No. 1, and that of the eye alluded to above, and waited on him a few days since to ascertain the result. He said they had been shewn to several eminent anatomists who resorted thither, and, in general, the plan was considered novel,—much approved,—and deemed highly worthy of an extended trial. The specimen of the eye, he said, was especially admired.

Great Prescott street, Feb. 1, 1817.

A Case of Amputation, with some Experiments and Observations on the securing of Arteries with minute silk Ligatures. By JOHN CROSS, Surgeon at Norwich, Author of "*Sketches of the Medical Schools of Paris*;" late Demonstrator of Anatomy in the University of Dublin, &c.

[From the London Medical Repository.]

ABOVE fifteen months have elapsed since Mr. Lawrence published an interesting paper in the *Medico-Chirurgical*

Transactions,* on "a New Method of Tying Arteries;" and although the proposal of so able and celebrated a writer must have been received with eagerness and speedily adopted in practice by many surgeons, no additional information upon the subject has since been offered to the public. In the absence of communication from better sources, therefore, I have found the motive for putting together the few trials I have made, and begging the Editors of the *Repository*, if they should think them worthy of such a distinction, to submit them to the consideration of its numerous readers.

The originality of Mr. Lawrence's suggestion, to use fine silk ligatures, and cut them off close to the knot, has been questioned upon insufficient grounds. He not only seems to have undertaken this plan without knowing what was doing or had been done by military surgeons on the continent, but to have had a different view in the practice he suggested.

The number of sick that were often crowded into the same hospital, and the excessive fatigue which the soldiers had previously undergone, contributed to render the hospital gangrene very prevalent and destructive towards the conclusion of the late war. The progress of this disease was nearly in proportion to the extent of the wounded surface exposed; and whilst small wounds sometimes escaped, large ones were almost sure to suffer. Hence the military surgeons, who were the first in France to adopt the English plan of uniting stumps by the first intention, derived an additional motive for recommending it. Immediate union after amputation, diminished the frequency of hospital gangrene, but did not altogether prevent it, the ligatures keeping up a suppurating surface, which communicated with the external air. To avoid this inconvenience, the ligatures were cut off close to the knot, and the stump accurately closed; and as often as complete union took place, the patient was secured from the contagious disease.†

Most new things originate in some suggestion from existing circumstances. Whether the military surgeons of France or England were the first who cut the ligatures short, I am unable

* Vol. vi. p. 156.

† "Pour éviter cet inconvénient," says M. Delpech, "nous avons pris le parti de ne plus réserrer des bouts de ligature, et de couper les fils contre le nœud, afin de n'avoir plus d'interposition, et de pouvoir faire une réunion exacte et complète. Dès lors n'ayant plus de plaie extérieure, nous n'avons plus eu de pourriture à la suite des amputations."—*Mémoire sur la Pourriture d'Hôpital*, par J. Delpech, p. 29.

to determine ; but the former seem to have tried it to the greater extent. Those who have noticed it in their writings, say nothing of the kind of ligature employed, from which we may fairly conclude that they use those of the common size ; and although they probably never dreamt that the ligatures thus buried would be absorbed, or remain quiet in the stump for life, they were justified in leaving them to their fate, with the hope of obviating one of the worst complication of wounds with which the military surgeon has to contend.

The ligatures were afterwards cut short by many surgeons in the army, without reference to the occasions that first rendered the practice advisable. When, however, there was no contagious disease to be prevented, the advantages gained were so small as to be easily outweighed by the unpleasant consequences that sometimes followed ; and an excellent modern writer on Military Surgery has given his testimony decidedly to this effect : when the short ligatures have been buried in a stump, "I have seen,"* he says, "some ill looking abscesses formed by them, and I suspect some disagreeable consequences will occasionally ensue, if this practice be continued."

It is so well known that a stump will unite over a ligature of the common size, that the teacher has to direct the young surgeon to be careful in bringing all the threads out of the wound, lest such an occurrence should take place, and lay the foundation of future mischief. I have seen suppuration and breaking out of a stump six months after amputation of the fore-arm, and a ligature an inch long discharged, which had been overlooked in the closing of the wound, and buried under the integuments ; and the blunders of operators have, no doubt, given many others an opportunity of ascertaining the same fact.

The use of ligatures of the finest silk, cut off close to the knot, is not proposed by Mr. Lawrence to guard against any prevalent and destructive disease, but to obtain a more speedy and complete union of wounds after operations, and to diminish the chance of hæmorrhage, by avoiding the irritation which large ligatures excite ; and the statement which he detailed of his experience, gave me so much confidence in the safety of the practice, that I was induced, without previously making any experiments on animals, to try it, soon after that gentleman's paper came to my knowledge, in the following case of amputation.

- * Guthrie on *Gunshot Wounds*, p. 94.

M. E., a young woman, with engaging features and small, well proportioned body, aged 23 years, was seized with violent pain of her right knee, two years before, when in bed, and was soon succeeded by a degree of swelling. The disease, from this beginning, went on progressively; the particulars of its history I do not know, nor would they, collected from report, be of much value. Fomentations, blisters, and mercurial ointment, had been used at different times, previous to the occurrence of suppuration. During the last four or five months, she had been under the care of a particular friend of mine, a most respectable surgeon, who had evacuated abscesses around the joint, and kept open issues on each side of it for many weeks.

I visited this patient on the 26th of January, 1816; her suffering and the state of the diseased joint were such as called for the operation I went to perform. Her easiest posture was on the back, with the thigh drawn up towards the abdomen, the affected knee being permanently bent to a very acute angle, and the slightest attempts to alter the angle of flexure causing excruciating pain. The issues had been healed; there were two sinuses discharging ill-conditioned matter. Above the patella, was a swelling, extending three inches up the forepart of the thigh, and bulging out on each side of the tendon of the rectus femoris muscle, which seemed to contain a fluid. The thigh was wasted so as to give the knee an appearance of being greatly enlarged. The patient's health had not suffered seriously, so as to make the performance of amputation of urgent necessity; but she was tired of long protracted suffering, and had firmly made up her mind to the only means which, in such a state of disease, could afford her permanent relief.

It is unnecessary to mention the particular steps of the operation. In making the circular incision of the integuments, I had some difficulty in bringing my hand underneath, in consequence of the acute angle which the leg made with the thigh; and this compelled me to cut higher than otherwise was absolutely requisite. All the parts cut through were in a healthy state, the incision being some way above the swelling on the forepart of the thigh. I had with me some of the smallest dentist's silk that I could procure, yet of such strength that I could hardly break it by pulling with my hands, on account of its cutting into my fingers; with this I tied the main artery, (pulled out with the forceps so as to be free from all surrounding parts,) and immediately cut the thread off close to the knot. The tourniquet was then loosened, and five or six smaller vessels tied, being taken up with the forceps and separated as much

as possible from surrounding soft parts. Upon some of these I only put one, upon the rest two, of the three twists which composed the silk with which the main artery was tied. I found an inconvenience from having cut off the first thread close to the knot immediately after applying it; in looking for other vessels I did not know exactly where the ligature already applied was situated; and, had it been on a smaller vessel, there might have been danger of my pulling it off with the forceps in searching for other vessels, as the stump was very little disposed to bleed. I therefore consider it a useful caution not to cut off any of the threads close to the knots, until all the vessels requiring it are tied. I observed this rule with respect to the smaller ligature; when I had cut these off, I brought the skin accurately together by strips of plaster, leaving a small space between each strip, and put on a very light covering of linen. After I had applied one or two strips of plaster, I pressed out several bubbles of air from under the skin, which, if left, would have done much mischief, increasing suppuration, and preventing adhesion by keeping the surfaces of the wound from being in contact. It is of considerable importance to be thus careful in dislodging every particle of air in closing the stump; the air is most likely to lodge where the integuments are abundant.

On the morning after the operation, the stump was easy and cool, and the dressings scarcely soiled with the discharge. On account of her residence being at a great distance from Norwich, I did not see the patient again; and the first report I received from the surgeon who continued to attend her, was not very flattering, a considerable quantity of unhealthy matter having escaped on taking off the dressings on the fourth day, and vesications having formed on the face of the stump. The reply which I made to this report will give some notion of it:—"As you seem to despond of our patient, I must do so too; but I confess you have not furnished me with all the grounds of such an opinion, unless I consider her being "placid and willing to die" as bad signs; for people are rarely willing to die, until they think there is no longer any chance for their living. The bad signs must be drawn from the pulse, the spirits, and the appetite; and if, in these respects (about which you have told me very little) there be nothing very unfavourable, I cannot think that matter forming, and a stump not uniting immediately, are sufficient reasons for at once desponding. If the integuments of the stump be flabby and inactive, it should, perhaps, rather be kept warm, and action promoted. At any rate do not let the patient sink for want of

the strength being supported by good broth, bark, and cordials if required ; and, as matter must form, leave a free opening for the discharge of it."

On the eighth day after the operation, I again heard of the patient. Her health had been improved by bark and nourishing diet ; and cold applications, aided by the fan and bellows, had been found necessary for conducting off heat from the stump. At the end of three weeks, there was only a quill-hole opening on the face of the stump, discharging matter ; the rest of the stump being very neatly united.

Six weeks passed away before the stump was quite healed ; and during the four or five succeeding months, small collections of matter were repeatedly formed, and discharged ; the patient being, however, able to go about well, with the assistance of an artificial leg. In January last, twelve months after the operation, I learnt that the stump continued to be soundly healed. None of the ligatures left on the arteries were found in the discharge from the stump ; but I do not regard this as an argument that they were not discharged, as the researches for them were slight, and the secretion of matter very abundant.

A short account of the appearances found on dissection of the amputated limb, will not, it is hoped, prolong this paper to a tedious length.

The external openings, which had formed at different times for the evacuation of matter communicated with large cavities on the inner and posterior parts of the knee, extending half way down the leg, above the fascia enveloping the muscles. The swelling above the patella, which was supposed to contain matter, consisted of a semi-transparent gelatinous mass, streaked with white opaque lines, into which the synovial membrane at that part had been converted. This mass, in some parts two inches in thickness, formed convex prominences, on each side the tendon of the rectus muscle, which were covered thinly by the expanded vastus internus and vastus externus muscles. The synovial membrane on all sides was diseased, in some parts being firmer and less gelatinous than just mentioned ; in other parts of a light brown appearance ; in others ulcerated through, forming communications between the superficial abscesses first described, and the cavity of the joint. The semilunar cartilages and their ligaments were entirely gone ; the corresponding surfaces of the tibia, femur, and patella, were denuded and rough. The parts of the articular surfaces of these bones, which were still covered with cartilage, had it very slightly adhering to them, and no synovial membrane upon them. There was no pus accumulated in the cavity of the joint, but

its surfaces were bedewed with a brownish discharge, like what used to flow from the external openings. The head of the tibia was soft enough to be cut with the scalpel, but none of the bones were enlarged. The lateral and crucial ligaments were healthy. The fixt and bended position of the limb seemed to be owing to contraction of the flexor muscles, and not to the diseased structure preventing the motion of the joint; for, after the diseased mass was taken away, the joint still remained fixed until the flexor muscles were cut through. The diseased mass, as it has appeared to me, from this as well as other instances, limits flexion and extension, but never goes so far as to fix the joint completely. There was much fat around the joint.

This is rather a striking example of the disease described by Mr. Brodie, in the fourth and sixth volumes of the *Medico-Chirurgical Transactions*, under the title of a Morbid Change of Structure of the Synovial Membrane. Like other morbid structures, it tends, after having proceeded to a certain extent, to go into ulceration; and this process, I am inclined to believe, commences generally on the outer surface of the diseased mass, and proceeds inwards towards the cavity of the joint. The superficial abscesses, which form before the joint becomes exposed, come in aid of this opinion; and I have repeatedly seen ulceration on the external surface of this morbid structure, without its extending deep into it.*

The use of the minute silk ligatures requires dexterity, and is attended with difficulties that amount to strong objections in

* I have seen only one instance of this disease in the elbow joint. Amputation was performed at an advanced period; the diseased structure projected like a fungus over the edges of the articular surfaces of the joint, which were ulcerated and rough; and superficial abscesses communicated with the cavity of the joint by ulcerated holes through the diseased mass.—I have no doubt that the *Gliedschwamm*, or *Fungus Articulii* of German writers, refers to this disease. Böttcher, following the account first given by Brambilla, describes the disease as “increasing slowly, free from pain at the commencement, elastic to partial pressure like a sponge; and when there is much deep-seated pain, it indicates that the disease is complicated with suppuration and caries.” The disease was considered to originate in the appendages and cellular substance around the joint, the anatomy and structure of the synovial membrane being at that time little understood. The morbid growth is certainly not long confined to the synovial membrane, but involves the neighbouring parts and converts them to its own nature; for after injecting a limb which had been removed on account of this disease, I have found the superior articular arteries, passing through the midst of the morbid and gelatinous mass, to reach their usual distribution.—(See Böttcher, *Krankheiten der Knochen, Knorpel, and Sehnen*. Band, 3, S. 225.)

the hands of many who have to perform operations. The vessel ought to be drawn out clean from all the surrounding parts, which is not always very practicable; and it may even be necessary, when there is a rapid oozing of blood from any spot, to use the tenaculum, and take up some of the soft parts with the vessel; in which case, to cut the ends off close to the knot, with a view of leaving the ligature to be buried in the stump, would be objectionable, however small the ligature employed. The experimentalist, who feels more than a common interest in the result of his trials, may give a degree of attention that will obviate all lesser evils; but in estimating a practice that is proposed for general adoption, we must calculate upon no more than a moderate share of attention and dexterity in the operator. It is clear to me that the surgeon, who has not a microscopic eye, will be longer occupied in applying the minute than the common ligature; the patient will be kept longer on the table, and the stump exposed for a longer time. Convinced of these points, I was desirous of prosecuting some experiments which might contribute to ascertain the advantages of the practice in question; an undertaking in which there was no great presumption, as Mr. Lawrence had acknowledged that he had not gone far enough in his inquiries to make up his mind upon the subject.

Experiment 1st.—I exposed the right* carotid artery of a large rough coated water dog, and tied it with very fine Indian silk, which I could just pull tight enough, without danger of breaking it, to compress the artery. At the expiration of a fortnight, I put a single ligature of the same kind on the left carotid. The wounds from both operations healed quickly. The dog continued healthy, and became fat. Seven weeks from the first operation he was killed and injected. The injection was continuous throughout the whole of the right carotid, but the vessel was contracted at one part to half its former diameter, the ligature having only been drawn tight enough to compress, without obliterating the vessel. I found the ligature surrounding this contracted part of the vessel, buried in, and every where in close contact with a substance more dense than the arterial coats; I only detected it by very careful dissection,

* I preferred the carotid, because it is situated so much deeper than the arteries of the extremities. The coats of the vessel were dissected clean before the ligature was applied, and the threads were always cut off close to the knot. In the instances in which dentist's silk was used, it had been previously washed.

and the help of a magnifying glass. The knot was perfect, and the whole circle of the ligature entire. The left carotid presented very different appearances; two inches of it were obliterated, and converted into a dense cord, which was swollen out a little at one part to the size of a coriander seed; and here I found the ligature, surrounded by a firm and almost ligamentous substance.

From their situation, I am inclined to believe that these ligatures would have remained during the life of the animal. The history of extraneous bodies in the living system affords nothing in favour of a contrary supposition. Extraneous substances, after lying a long time buried and concealed, have excited suppuration, and made their way out of the body; but they have been weighty; and on this or some other account, have gradually changed their situation, until, coming near the surface, they have excited irritation, and given rise to a process which has enabled them to be discharged. Supposing these ligatures would cause suppuration, and be discharged externally, when brought near the surface of the body, their weight is not sufficient to change their place, and bring them into such a situation; nor is there any other process by which they are likely, as far as I can conjecture, to be transferred near to the surface of the body, when once surrounded by a firm ligamentous structure.

It is necessary, however, to consider the difference between applying a ligature to the continued trunk of an artery, and to the extremities of vessels exposed by operations. In the latter case, a portion of the vessel becomes nearly insulated, and the sloughing of this may involve the fate of the ligature. In subsequent experiments, I endeavoured to profit by this observation.

Experiment 2d.—I tied the right carotid artery of a thin small dog with one of the three threads which compose the smallest dentist's silk. I put on two ligatures, at the distance of half an inch from each other, and divided the vessel between them. In forty-eight hours the wound was soundly united, and I therefore took out the three stitches with which the wound had been brought together, lest, by remaining, they should cause the wound to burst open again.* The left caro-

* This remark is equally applicable to the human subject. Whenever sutures are used, they loosen themselves by the second or third day, and can do no good by remaining longer, but very often do harm, by causing inflammation, and re-opening of the wound.

tid was tied, three weeks afterwards, with a single ligature of the same size; the animal tore the wound open, and it was not united until ten or twelve days. Six weeks from the first operation, the animal was killed and injected. The two ends left by the division of the right carotid were an inch distant from each other. Near the upper end of the vessel, there was a swelling bigger than a pea, which proved to be a cavity filled with matter; and, on puncturing it, the matter escaped, and with it one of the ligatures. I did not find the ligature which had been applied to the other end of this vessel. The left carotid was impervious for the fourth of an inch. The parts were all sound, and no ligature to be detected; it had probably escaped by the external wound, which was so long before it healed.

Experiment 3d.—I put a single ligature of the smallest dentist's silk on the left carotid of an ass. On the same day, my friend, Mr. Stevenson, put two similar ligatures on the right carotid, and divided the vessel between them. The wounds suppurated, and much matter was discharged, in which the slough of one end of the right carotid was observed. On the sixteenth day from the operation, this animal was attacked with tetanus, and died on the twenty-sixth. Neither of the wounds had completely healed. On dissection, I found the three ligatures under different circumstances. On the right side, there was a purulent cavity down to the ends of the divided vessel, which were an inch and a half asunder, and both ligatures were found in the matter contained here, wholly unconnected with the artery. There was also the slough of one end of the divided artery, imbedded in matter, and unconnected with the ligature. On the left side, there was a cavity of pus at the part where the vessel was tied, and the ligature was firm upon the artery, not however covered over with any healthy living structure, but in contact with matter.

Experiment 4th.—A dog was kept four months after the application of very minute silk ligatures to each carotid artery. Both arteries were obliterated, the parts all sound, but no ligatures could be detected by the most careful examination. The probable explanation is, that the ligatures had escaped unobserved before the wounds closed, as these did not unite by the first intention. The results of other experiments render it quite unlikely that they were absorbed.

Experiment 5th.—Two ligatures of small Dutch twine were put on the left, and one on the right carotid of a dog, the ends being cut off close to the knot. On dissection, seven weeks

afterwards, I found each of the ligatures in a small bed of matter, of the size of a pea, near the vessel to which it had been applied.

Experiment 6th.—I tied the right carotid of a young dog firmly with one of the three threads which compose the smallest dentist's silk. Three weeks afterwards, I tied the left carotid with two ligatures of the same size, and divided the vessel between them. Both wounds healed quickly and remained healed. The dog was killed at the end of thirty weeks, and successfully injected. On the right side, I found three quarters of an inch of the artery obliterated, and the ligature unconnected with it, being buried in a small quantity of brownish matter. On the left side I met with a similar abscess, of the size of a pea; and in the matter which it contained I found both the ligatures which had been applied to the artery precisely twenty-seven weeks before. The ends of the divided vessel had contracted so as to be above an inch and a half apart; hence it seems that these ligatures must, at one time, have been contained in separate abscesses, which had approximated until they coalesced.*

On both sides, I found a small vessel or two proceeding from the lower to the upper portion of the artery, as if nature had begun the work of forming a substitute for the part obliterated, in the way described by Dr. Parry. This is the only instance in which I have seen this process taking place, probably because I have not examined the parts at a sufficiently remote period from the obstruction of the circulation by ligature. These communicating branches were not above one-fortieth of an inch in diameter. Their enlargement seems to be a very slow and gradual process; but there is no reason why it should not go on after having once commenced, until the motive for this enlargement no longer exists, the blood taking the most direct course to the parts to be supplied with it.

The experiments which I have detailed, have, in some respects, afforded different results from those which Mr. Lawrence made, and lead to the following conclusions, which are not very favourable to the employment of the minute silk ligatures after operations.

1st. If the wounds do not unite by the first intention, the ligatures may escape with the discharge, without any inconvenience.

* This may help to explain why I failed to find one of the ligatures applied to the right carotid in Experiment 2d, where the wound healed too quickly for it to have escaped.

2d. If common ligatures of twine are cut short, the wound may unite over them, and they may be found in abscesses after an interval of many weeks.

3d. If the finest dentist's silk be employed in the same way, the wound uniting over it, the ligature may be detached from the vessel, and remain buried in an abscess, where it will be found at different periods, from one to seven months; and this may happen, whether the vessel be firmly compressed with a single ligature, or divided between two ligatures, so as to imitate the circumstances under which vessels are tied after operations.

4th. If Indian silk, fine as a hair, be put round a vessel, so as to diminish its diameter, or to effect its obliteration, by just compressing its sides together, it may remain in this situation without exciting abscess, or producing any inconvenience. The ligature may be thus applied to compress an artery for the cure of aneurism; but not to secure vessels divided by operations. If a thin ligature be drawn sufficiently tight upon a vessel on the face of a stump to be secure, I am persuaded that the extremity of the vessel, which becomes insulated, as it were, must die. How often do we see this slough of the main artery of the thigh come away with the ligature!

Mr. Guthrie considers that cutting the common ligature close to the knot is a valuable improvement in all cases, that will not unite by the first intention, which is following the practice with a view diametrically opposite to that of its advocates; and I should almost have been tempted to say as much of the minute silk ligatures, had they not been recommended by a high authority. To heal a wound so quickly that these ligatures become buried, seems, however, no desirable object; since they frequently, if not always, excite abscess when applied to the deeply seated carotid of an animal possessed of a system much more capable than the human of resisting violence and repairing injury. The minute silk ligatures seem to secure well the vessels to which they are applied; and so do common ligatures of silk or twine; hæmorrhage from the vessels which have been tied being a rare occurrence in a healthy wound. The minute ligatures, when firmly tied, separate quickly, and pass away with the discharge; the common ligature, tied tight, also separates quickly, and might be removed much sooner than generally happens, were it not for the unfounded fears of the surgeon. The end of a ligature sometimes rises half an inch further out of the wound than at the preceding dressing, but resistance is felt because the granulations have grown so as to form an isthmus too narrow for

the knot to pass. Where this change has taken place, no danger is to be apprehended from bringing the ligature away, as it is already at a distance from the artery to which it had been applied.

Ought the surgeon readily to give up the comfort of knowing that all the ligatures, particularly the one from the main artery, are away? Have the minute short ligatures any other advantages than that of avoiding the irritation of threads hanging out of the wound? Are there not sufficient objections to their being employed generally in practice, however applicable to particular cases? May not the surgeon, who is less frequently engaged in operating, include with the artery a neighbouring nerve?

I conclude with these queries, under the hope that those surgeons, who have been captivated with Mr. Lawrence's ingenious proposal, may answer them by giving publicity to their experience upon the subject.