

case of George the Second, pointing out an error of Dr. Forbes in the notes to his translation of Laennec, in which it is stated that the monarch died from aneurysm of the aorta, whereas the death happened from rupture of the right ventricle. But an aneurysm was found in the aorta. The inner and middle coats had given way transversely, as in Dr. Elliotson's patient, and allowed the blood to pour forth under the outer coat, and distend and elevate it. The mischief, however, had proceeded no farther, the outer coat not having given way. So far from the "first authority of the day on the subject"* being right in saying that aneurysm cannot occur here, and that because "the part of the aorta referred to is destitute of a cellular tunic, and the pericardium which supplies its place not being equally distensible, bursts rather than dilates into a false aneurysm, Dr. Elliotson pointed out to us that Dr. Nicholl, who examined the body of George the Second, and published an account of the examination in the *Philosophical Transactions* for 1761, says, "This appearance showed the true state of an aneurysm of the aorta, and confirmed a doctrine which I had the honour to illustrate, by an experiment to the satisfaction of the Society, in 1728, viz. that the external coat of the aorta may, and often does, control an impetuosity of the blood capable of bursting the internal and ligamentous coat." I am, Sir, your obedient servant,

A STUDENT AT THE LONDON
UNIVERSITY.

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ON THE

TORSION OF ARTERIES

FOR THE PURPOSE OF ARRESTING
HEMORRHAGE.

By W. B. COSTELLO, Esq., London.†

It was originally my intention, in bringing the subject of the torsion of the arteries under the notice of the Westminster Medical Society, to state merely what I had seen of that process during a visit which I have lately made to Paris, and to express, in addition, my gratitude to M. Amussat, for his kindness in directing the experiments I then performed, under his eyes, on this interesting point. But in meditating on the subject, I have found it

so deserving of an ample *exposé* in this country, that I have resolved upon giving such a view of it as will connect it with the other hæmostatic processes now in use in surgery, most of which are of very high antiquity.

The arrestation of the current of blood, according to that excellent observer, Jones, depends on the formation of a *co-nical clot* in the arterial tube, on the retraction and contraction, or puckering, of its extremity, and on the pressure of the parts surrounding the cut end of the vessel. When these causes are sufficient, as they often are, to stop hemorrhage from small vessels, of course all other means are dispensed with. Koch, of Munich, is in the habit of relying on this spontaneous ceasing of the flow of blood, and favours it by the position of the limbs, in cases of amputation, as well as by the application of cold lotions.

Hemorrhage is also stopped by *laceration*. Of this we have an example in the removal of certain tumours, where the vessels that supply them, or with which they are connected, might forbid the use of the knife. When a limb is torn off, the vessels which have been drawn violently out, retract in some degree, and no blood flows. In this we have an instance of the influence of laceration and retraction combined. It is well known, that when "littering," certain animals separate themselves from their young by gnawing asunder the umbilical cord; and Jones has shown, that if an artery be pinched and jagged, the internal tunics are torn, and assist the formation of the clot, and prevent hemorrhage.

Again, if a small divided artery be drawn out, and turned down on itself, until the clot has had time to form, the blood ceases to flow. This method has been successful in the intercostal artery, and others of small caliber. *Styptics* of various kinds and in various modes have been used for the same purpose. Thus, small cones of alum or sulphate of copper have been used as corks in the mouth of the cut artery. These means have justly fallen into disuse. Talrich's styptic has been tried; but it appears useful only in small vessels. Agaric, amadou, cobweb, sponge, and powdered resin, have been looked upon as endowed with a styptic power; and, in capillary hemorrhage, solutions of sulphate of iron, sulphate of copper, of alum, or nitrate of silver, are found effective.

Cauterization is now but little used, except in operations on the rectum or uterus. In such cases the iron is usually applied at a white heat, on the mouth of the vessel, to which it is passed down through a conducting tube of the same metal. If the iron be not at a white heat, it adheres to

* This title belongs to no man more truly than to Dr. Elliotson.—ED. L.

† Communicated to the Westminster Medical Society, February 8th, 1834.

the eschar and detaches it, so that the blood continues to flow; and even when it is applied at the proper heat, if it be allowed to remain too long the same effect will follow.

Compression is of great use, and is of two kinds, direct and indirect; direct when the vessel is commanded by the finger of the surgeon, in a small wound, or a flap amputation, or with the graduated compress of agaric, lint, or folds of linen, &c.; indirect, when it is established at a distance from the wound, by the tourniquet or any other means. It is needless to remark, that these different modes are resorted to, separately or in combination. I have seen a capillary hemorrhage which could not be checked by direct compression until the femoral artery was compressed.

Koch of Munich's method after amputation, consists in joining the flaps by bandages, placing a long compress on the artery, and raising the limb. An assistant keeps up a gentle and continuous pressure for several hours, and until the pulsations are observed to become weaker in the stump. He considers the danger from hemorrhage to be at an end when the dressing becomes dry and stiff, which it does within twelve or twenty-four hours.

The *ligature*, the thought of which Paré looked upon as an inspiration vouchsafed to him by the Almighty, was not, however, an invention of his time. It was described by the ancients. A description of this method, comprising its effects on the artery, the substance of which it should be made, the manner of its application, &c. would form subjects ample enough for the consideration of an entire evening. Happily being the plan most in use, it is also the best known, and, therefore, in this assembly especially, the details which belong to it may be omitted. I shall merely add that Jones recommends the use of a very slender thread of silk, applied tightly enough to cut the internal tunics of the artery. Of the application of ice and temporary ligatures I need say nothing.

The operation of *torsion* has in its effects great analogy to the ligature, and seems capable of supplanting the ligature in many cases. It is simple, and in saying this we give it the highest recommendation that can be bestowed on a surgical process. The merit of its invention belongs, undoubtedly, to M. Amussat, and would, if he had no other of his numerous claims to fame, suffice to render his name illustrious amongst the surgeons of the present age. As I have said before, there is nothing new in crisping, jagging, or even turning on its axis, a divided artery in order to stop hemorrhage; for from the time of Galen to our own time, this process was

known, but the operation of torsion,—in the sense which is now attached to the word torsion—methodical in its arrangement and certain in its effects,—is an entirely new and most valuable hæmostatic process.

M. Amussat having observed that in gun-shot or contused wounds, or in great lacerations of the limbs, even large vessels rarely bleed, imagined, that by imitating this contusion of the vessel, the same effect must follow. In order to test this idea, he instituted a series of experiments, which, however, led to no decisive result. But he was struck on one occasion, in which he had twisted the artery, with the fact, that it furnished no blood, and thus an accident developed the truth which his reasoning from other facts had anticipated.

I shall now describe the manner in which M. Amussat practises torsion. He seizes the divided vessel with a pair of torsion forceps, in such a manner as to hold and close the mouth of the vessel in its teeth. The slide of the forceps shuts its blade, and the artery is held fast. The artery is then drawn from out of the tissues surrounding it, to the extent of a few lines, and freed, with another forceps, from its cellular envelope, so as to lay bare its external coat. The index and thumb of the left hand are then applied above the forceps, in order to press back the blood in the vessel. He then begins to twist the artery. One of the methods consists in continuing the torsion until the part held in the forceps is detached. When, however, the operator does not intend to produce that effect, he ceases, after from four to six revolutions of the vessel on its axis for the small arteries, and from eight to twelve for the large ones. The hemorrhage instantly stops. The vessel which had been drawn out is then replaced, as the surrounding parts give support to the knot which has been formed at its extremity. The knot becomes further concealed by the retraction of the artery, and this retraction will be proportionate to the shortening which takes place by the effect of the twisting, so that it will be scarcely visible on the surface of the stump. It is of the utmost importance to seize the artery perfectly, and to make the stated number of twists, as otherwise the security against the danger of consecutive hemorrhage will not be so perfect.

It has been already stated, that when we apply a ligature, the internal tunics of the artery are divided. In the torsion, these tunics are also divided, but in comparing one with the other, there will be this difference,—that in the case of the ligature, the internal tunics, though de-

tached from the cellular coat, remain, nevertheless, close to it, so that there exists but very little space between them; but in the torsion these tunics ascend, and take a position in the middle of the clot, to the rapid formation of which they contribute, and the clot itself extends to the next collateral; a space exists between the knot and the internal tunics, in which the cellular coat inflames, when plastic lymph is thrown out, and the first obturation of the end of the vessel is effected. The same process of exudation takes place from the internal tunics higher up, and the clot thus becomes adherent to the circumference of the arterial tubes, and thus also the obliteration of the vessel is rendered doubly secure.

Experiment 1.—M. Delcroix, M. Amussat's assistant, laid bare the femoral artery of a middle-sized dog, when I applied two pairs of forceps on the vessel, which I divided in the interval, and, according to the process described, twisted the upper end eight times, and replaced it. There resulted no hemorrhage. I then twisted the lower one, but not being *au fait* of the manœuvre, which I should observe requires tact and practice, it was imperfectly effected. Consecutive hemorrhage came from the lower vessel, which I sought, and again seizing it and freeing it from its connexions, I twisted it eight times, when the hemorrhage instantly ceased.

Experiment 2.—I laid bare the femoral artery of a large dog. The vessel was of large caliber; I proceeded as before, and no hemorrhage took place.

Experiment 3.—The carotid of a mastiff was laid bare, and I practised the torsion as before. The size of the vessel was considerable. I twisted the vessel on the side of the capillaries eight times, and on the side of the heart until the rupture of the portion held in the forceps was effected. No hemorrhage ensued from either.

Experiment 4.—The femoral of a large dog was laid bare, and was twisted in the usual way on one side, until rupture was effected, and on the other until a knot only was formed. I now, at M. Amussat's suggestion, untwisted the knot. No hemorrhage followed, although the knot was entirely untwisted.

Experiment 5.—In another experiment the epiploon of a dog was exposed, and a portion of it removed. The divided arteries, which were numerous, furnished blood abundantly. They were seized and twisted two or three times each, when the hemorrhage ceased.

It would be tedious to prolong the recital of experiments, for they invariably,

and under whatever circumstances performed, furnished the same results.

Another illustration of the efficacy of torsion will be found in the torsion of any given artery, the radial for instance. If a syringe be applied higher up, and water be impelled from it through the tube of the twisted vessel, the knot will be raised up, but it will remain untwisted, and not a drop of water will pass, no matter what force we employ.

In examining minutely what takes place in the twisted artery, we find the internal membranes twisted and forming a cone, of which the apex is directed towards the heart. If we cut this cone longitudinally, it presents a clot of blood which is strongly adherent to the inner coat of the artery, and which completely stops it up. If we examine the artery, at a certain distance of time from the period of the operation, we find this clot and membranes solidified, and the vessel obliterated as far as the next collateral.

So much for experiments on the lower animals.

The method of torsion has been employed in operations on the human body with the same results. M. Amussat himself now employs no other hæmostatic method, and I can state that he has found it successful, in castration, in amputations of the thighs, arms, &c., and in the disarticulation of the shoulder-joint. M. Fricke, of Hamburgh, is so satisfied with this method, that he employs no other, either in his private practice, or in the hospital over which he presides.

The frequent examinations which M. Amussat has had an opportunity of making on the effect of the torsion of arteries, have suggested to him another method, which he calls *refoulement*, or *pushing back into the arterial tube the divided internal membranes*. The refoulement of these membranes is effected without any division of the artery. The vessel is simply laid bare, and seized with a forceps, beaked in the usual way, but which, above the beak, is rounded in both blades. The artery is pressed strongly between the rounded part of the blades, and thus the internal membranes are cut. Another and a similar pair of forceps is now fixed on the flattened vessel, and the membranes are pushed back, or *refoulées*, by a zig-zag movement of the first forceps. One, two, or three, or more, of those *refoulements* or *machures* may be made; and from some of the arteries treated in this way I saw the following results. The outer or cellular coat inflames, and plastic lymph is exuded. The internal membranes fall into the same circumstances as in the case of torsion, but with this difference,—

that the number of diaphragms arranged to form clots, is in the ratio of the *machures* made on the artery.

In no instance, when properly employed, either in animals or in man, has the twisted artery been observed to ulcerate, or become gangrenous. Its effects, and the organic changes which it produces, appear to be these:—the internal membranes are broken; they become narrow, or, rather, roll up and join, so as to form a *cul de sac*; they pour out plastic lymph, which adheres to the clot, which is formed immediately and invariably between this point and the nearest collateral. The outer membrane forms another *cul de sac*, and its internal surface pours out plastic lymph also. A similar process takes place between the outer surface and the surrounding parts.

Let us now see what takes place when the ligature is employed.—1st. Jones states that the middle and inmost membrane, when cut by the ligature, join, and that the cellular membrane remains entire, the blood passing through the collaterals.—2nd. A clot is formed in the arterial tube, if there be no collateral vessel immediately near it.—3rd. An inflammation of the cut membranes takes place, and they become agglutinated by the plastic lymph which they pour out. The same process obtains on the outer surface.—4th. The portion of the artery, comprised in the ligature, ulcerates, and it is only when this process is complete that the ligature drops off.

We can now appreciate the advantages or disadvantages inherent in either method. When *torsion* or *refoulement* of the internal membranes is employed, the wound may be united by the first intention. There is no foreign body in the wound, and there is no danger of consecutive hemorrhage.

When the ligature is had recourse to, there is a foreign body in the wound, which must be thrown off by ulceration or gangrene. It often happens that the ulcerative process extends to the surrounding parts, and consecutive hemorrhage takes place, when the end of the artery and the ligature are thrown off. Moreover, the external wound sometimes heals before the ligature is detached. In this case there is danger of an unmanageable fistula. One of the great advantages, therefore, of torsion is, that it allows immediate union of the wound, as will be particularly evident in hemorrhages of the epiploon, and in aneurysm of the carotids, for in the latter case there is great risk of the ligature giving rise to *fusées* of pus descending into the cavity of the thorax. The application of ligatures requires the

aid of an assistant. The torsion may be effected by the operating surgeon alone, and, undoubtedly, on the field of battle, this is an incalculable advantage. It is also but fair to infer from what precedes, that torsion may be of the highest importance, in operations which may be performed on the capillary side of an aneurysmal tumour.

* * In compliance with a request made by the Society on the evening that the subject of the foregoing communication formed a topic of debate, Mr. Costello attended to perform the experiments of torsion before the members at the meeting of the 22nd of February, when, after making a few prefatory observations on the cruelty of vivisection when the interests of science did not imperatively demand and fully justify it, he proceeded to expose the femoral artery of a terrier dog. The operation was performed with exactness and rapidity. The vessel being laid bare, and a probe passed under it, the members were invited to satisfy their minds that the vessel exposed was the femoral, by examining its size and pulsation, after which Mr. Costello placed two forceps on the artery in such a manner as to make the points opposed to each other leave but a very short interval between them. He then divided the artery between the two forceps, and commenced twisting the upper portion of the artery, and having counted five turns, he replaced it in the situation from which it had been drawn forth. For a short time there was no hemorrhage; he was now about to twist the capillary side of the artery, when the upper division gave out blood in a full stream; he instantly stopped the hemorrhage with his finger, and requested Mr. Quain, who was assisting him, to twist the other extremity of the vessel, which was still held in the forceps. Mr. Quain made eight turns, and having replaced the artery, not a drop of blood came forth. Mr. Costello now seized the upper end of the artery, and having twisted it seven times, replaced it. The wound was then examined by many of the members; there was not only no hemorrhage from either of the ends of the artery, but the wound itself seemed bloodless. The experiment was deemed to be so satisfactory, that the carotid was not exposed, as was at first intended, and the satisfaction of the Society was testified by much applause. The observations which were afterwards made by members terminated in a general assent to the reasonings of Mr. Costello and the value of the process demonstrated.
