ON
DELIGATION, FOR AORTIC ANEURISM,
OF THE
RIGHT CAROTID AND SUBCLAVIAN ARTERIES
WITH A NEW SPECIES OF LIGATURE.

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It will very probably be remembered by the Fellows of this Society, that I have already had the honour to bring to their notice four cases of double deligation of the carotid and subclavian vessels ; and that of these four, three have proved successful. The operations were undertaken for the cure of innominate aneurism. I now beg to record a fifth case of such operation performed for a different object, viz. for an aortic aneurism. The vessels were tied with a material hitherto unknown in surgery. As the remarks, which I feel to be forced upon me by the peculiarities of the practice, must of necessity occupy some space, the report of the case will be condensed within the narrowest possible limits.

On 8th February, 1879, Dr. Green asked me to see with him John S—. The man was thirty-six years of age but looked

older, the scalp hair being quite grey. His father died of heart disease. There is no history of syphilis or of rheumatism. On the right side of the upper part of the chest I found strong pulsation extending over a considerable space, but not limited by any clearly defined boundary line. At the same part was incomplete dulness, with similar lack of distinct definition. Pressure symptoms were entirely confined to the right bronchus, that side of the chest being almost immobile, but very little air entering the right lung, while the left side was hyper-resonant, the respiration puerile. Great oppression with some pain referred to about the right nipple was complained of. There was no perceptible or sphygmographic difference between the radial pulses. Dr. Green had treated the case, by the best means known in medicine, since the 9th January, but the aneurism was evidently increasing, and Dr. Green kindly handed the case over to me. In the week after our consultation his symptoms increased, and at last the right chest was entirely immobile. On the 15th Feb. I tied the right carotid and subclavian vessels with a ligature to be described in the sequel. The man recovered easily from the immediate effects of the operation. The right arm remained cold for six hours. Almost immediately, the sensations of oppression and the pain about the chest began to diminish, the patient saying he felt well; shortly after, pressure upon the bronchus very much declined—air entering the small bronchi—there seemed, since vesicular murmurs were weak, to be some difficulty of expansion in the lung itself, the bronchus appearing free. He continued in a very satisfactory condition till 28th March, when some highly vexatious domestic incident greatly excited him; he insisted on getting up, threw himself about, and was with difficulty dissuaded from leaving the Hospital. A day or two after, a pulsation further toward the left was detected, this increased to the middle of April, then became stationary and then declined.

13th, May.—Some increased pulsation is still perceptible over the first bone of the sternum, and a little way to the right of this bone as low as the cartilage of the second rib. The symptom has, however, very much decreased since the beginning of the month. - I have hopes, therefore, that

although the aorta, about the origin of the left subclavian, is dilated, a little further rest and treatment will improve this condition.

It should be noted that pulsation in the branches of the right carotid returned in a few hours, although none could be felt between the ligature and the bifurcation. Pulsation in the radial and brachial arteries was entirely absent for fifteen days. For another fortnight the radial pulse was only occasionally perceptible, and is even now very small. I have no doubt that, as in a previous case reported to this Society ('Med.-Chir. Trans.,' 1878), the whole subclavian vessel is obliterated.

The points of this case which require comment at my hands, are only two, but they are of very considerable importance, namely, the operation chosen, and the sort of ligature used. I will take them in that order.

The operation chosen.—As far as I am aware, no other case of aortic aneurism has ever been knowingly and wittingly treated by deligation of the right carotid artery, still less of that vessel together with the subclavian; I feel it, therefore, incumbent upon me to give my reasons for this choice. They are both theoretical and practical. In 1869, Dr. Cockle published some papers in the 'Lancet,' advocating in certain cases of aortic aneurism, deligation of the left common carotid artery. As far as I understand the author's able, but very condensed, remarks, he takes into account no other operation; at all events, his suggestions have been so acted upon by Mr. Heath, Mr. Holmes, and myself. In the cases of the two first-named surgeons, so much benefit resulted that the patients might practically be considered cured (Mr. Heath's patient suffered recurrence). In my own case, the disease was so far advanced that no cure, but merely prolongation of life and alleviation of suffering could be hoped for; these followed in even a greater degree than was expected. But in considering certain facts concerning the aortic arch, its branches, and the peculiarities of its blood-stream, I came to the conclusion

that distinctions must be drawn as to the operative treatment of aneurisms occupying different portions of that trunk.

Let me call attention to the mode of origin of the three great vessels, which has, I think, not attracted any attention. First, we see the great brachio-cephalic trunk, then, be it observed, there is no interval between that and the left carotid; there is not, as is usually figured and imagined, between these two vessels a bit of transverse aorta convex upwards, but a mere angle, a sort of V-shaped double septum. A little wider angle separates the left carotid from the subclavian. If the ascending aorta be severed from the rest a little to the proximal side of the innominate, and we look along the tube of the transverse part, we do not see the orifices of carotid and subclavian foreshortened into an oval or mere slit, as would be the case if these vessels were given off straight and plumb from the parent stem. On the contrary, these openings look nearly round, we seem to see right into the lumen of each branch, chiefly into the carotid. This results from the mode of origin of these large branches; they are not given off straight and rectangular from the transverse aorta, but, on the contrary, their roots take a very oblique direction to the left, and then swerve upward to assume each its proper course; hence the distal margin of each orifice lies on a level considerably lower than the proximal. Each such margin has running from it downwards, and to the right on each side wall of the aorta, a rounded ridge, so arranged that the projection of this distal lip, and two-fold spur—in shape not unlike a half funnel—catches the blood-stream as it courses along the main trunk and directs each its own share into its special branch. The arrangement of these ridges is such that they divide all the upper aspect, and a considerable part of the lateral surfaces of the aorta into districts, one for each vessel. Hence an aneurism, unless it spring from the lower wall of the transverse portion of the aorta, must almost of necessity belong to the district either of one branch or the other. Furthermore, there is no room on the upper surface of the arch between the innominate and left carotid for an

aortic aneurism ; such a tumour must belong to one or the other branch (see fig. 1).

FIG. 1.

Arch of the aorta and large branches in section. It shows the obliquity of the roots of the great vessels and the ridges running from their orifices upon the aortic walls.

Now to another consideration. When a concretion is detached from an aortic valve it almost invariably passes into the left carotid, sometimes into the left subclavian, into the right carotid only about once in twenty-five cases. This circumstance has given rise to the assumption that the left carotid lies more fully than the right in the axis of the heart and ascending aorta: the very reverse is the fact. If a little hole be made in each carotid just below its bifurcation and a probe be passed along each common trunk, as far as it will go without the use of any force, and, if then, the front wall of the chest &c., be removed, and the ascending aorta

carefully opened, the two probes will be found crossing within the vessel. The right one will be seen to pass through the aortic opening not far from its left margin, and to lie well in the ventricle. The left one strikes the tendinous ring of the aortic orifice on the right aspect of the vessel. In most bodies the end of the instrument will be just within the heart, in others it will be in the sinus of Valsalva. The probe is never in the axis of the ascending aorta, but strikes the wall, be it of ventricle or of vessel, at a considerable angle. We must, therefore, attribute this preference of detached concretæ to some truer cause. Solids within a stream, if not too heavy, go with the strongest current; therefore, it would seem that some subtle curve or slope of surface directs the most potent rush of the stream somewhat obliquely across the ascending aorta in the direction of the left carotid. In this course the current would pass from the right aspect of the origin of the vessel, towards the left carotid orifice; it would occupy that portion of the trunk which in fig. 2, lies to the left of the white probe. Probably the potent flow of blood in this direction and into the left carotid, is intimately associated with the preponderance of the left brain and of the right half of the body.

Now, if this be the more rapid part of the current, it follows that outside it, to its right there must be a slower stream—and it is easily comprehensible, that if the left carotid be occluded the force of the rapid current must be diverted towards the right, whereby the normally placid stream will be disturbed and rendered more turbulent. Hence it would appear that if aortic aneurism is to be treated by deligation at all, we must, as far as our means of diagnosis will allow, carefully distinguish between such as arise from one or the other portion of the aorta. I am, of course, well aware that in many instances such diagnosis is difficult—also that often the extent of vessel involved is so great that no such distinction exists, the disease over-stepping the boundary limits and in such cases the propriety of any operation is, to say the least, doubtful. But I also know by the teachings of much careful experience, that when the aneurism springs

FIG. 2.

from a fairly limited portion of the arch, observation as to the signs of pressure on the right bronchus or on the trachea, as to the tracing of the sphymograph, as to the particular veins chiefly or alone congested as to the place at which the tumour makes its appearance, as to the condition of the voice

and larynx, as to the place and direction of neuralgic pains, &c., indicate with very considerable precision the site of the disease. This has certainly been the fact in many cases that I have watched with minute care. The disease of John S. for instance, presented no diagnostic difficulties: the absence of venous congestion, or of any observable difference between the two pulses, the wide-spread character of the very considerable pulsation and its undefined boundary over the front of the chest, the perfectly free entrance of air to the left lung with almost entire occlusion of the right bronchus, defined the situation of the tumour with certainty, as being the back wall of the ascending aorta near the first angle and not far from the orifice of the brachio-cephalic artery. It belonged to the innominate, or, as I prefer to call it, the right aortic district. The two districts, right and left to the one or other of which, all aortic aneurisms amenable to operative treatment must be taken to belong, are probably separated from each other by a somewhat curved line running from the outer or right side of the aortic opening to the left carotid orifice. Thus to the right system will belong the right wall of the ascending aorta, and on the back and front wall a semilune, one of whose horns is at the outer valve, the other at the left carotid opening. Any operation for an aneurism in this district should be on the right vessels. The left district includes the left wall, a considerable adjoining space on the front and back of the ascending aorta, and all the transverse aorta from the proximal margin of the left carotid opening. Taking these considerations all together and applying them to the case of John S., it is evident that had I tied the left carotid instead of the right vessels I should have diverted the rapid current just described, and most probably to the right side of the parent stem, in other words toward the aneurism; and I should have injured rather than benefited my patient, whereas by occlusion of the innominate artery the quiet stream was rendered still more placid, and coagulation facilitated. The result has fully justified these considerations and even the symptoms of dilatation of the aorta in the distal part of the arch, help to prove this view. The

aorta at this part was not strong enough to bear the additional strain of an augmented stream especially when excitement was superadded.

If it be objected to me that all this about aortic currents is mere theory, I reply that I can imagine no means, whereby the presence or absence of differing rates of flow within the vessel could be absolutely demonstrated, that even if we could remove a living chest-wall and render the aorta transparent, we still could only see the relative force in different parts of the stream by watching the behaviour of floating solids. Nature often performs for us that experiment with the results just stated.

Nevertheless, I hold that theory alone hardly offers sufficiently solid foundation for an operation of this magnitude unless supported by some facts in practice. In the Museum of the College of Surgeons (Pathological series No. 1596A), is a dissected specimen taken from the woman upon whom in 1865 Mr. Heath performed deligation of the carotid and subclavian. As is well known, the diagnosis was inaccurate the aneurism being not innominate but aortic, solidification by coagulum took place, and be it observed the tumour occupies the right side of the ascending aorta—just that part which lies to the right of the white probe in fig. 2. Again, one of the patients whose case I reported here last December, Laura G—, had aorto-innominate aneurism, the aortic part being situated on the right front wall of that vessel. I tied the right carotid and subclavian. The patient is well and has lately married. Upon these practical illustrations of my views I founded the choice of operation.

Ligature used.—The deligation of large vessels near the heart is a far more fatal operation than the tying of arteries at a greater distance from the centre, and very much of this increased mortality is due to secondary hæmorrhage, indeed, this has been the invariable result of tying the innominate or the first part of the subclavian, therefore deligation with any ligature now in use of those vessels and of certain others somewhat similarly circumstanced, cannot in my opinion be justified. Mr. Erichsen in his work on surgery, gives fourteen

cases of each operation, all, I believe, that are on record. Of the innominate cases one bled, but was saved, two died before the period for bleeding arrived, eleven died of hæmorrhage. Of the fourteen subclavian cases, twelve bled to death, the others succumbed before the period of hæmorrhage. Although deligation of other arteries exposes the patient to less danger, according to their anatomical peculiarities, yet always there is some risk from this cause. In all the above twenty-eight cases the ligature used was silk or twine, that is, a material which divides the two inner coats, and then must come away by ulceration and sloughing of the outer tunic of the artery. It is plain that if under these conditions certain circumstances occur, still more if they concur, bleeding from one or other of the severed ends must inevitably result. One such circumstance, always present when the innominate, first part of the subclavian, or lower part of the carotid, is tied, is the neighbourhood of a large branch or vicinity of the ligature to the trunk, whence the vessel tied is derived. Moreover, the use of an insoluble ligature promotes suppuration of the wound and softening of the arterial coats. By the use of carbolised catgut combined with any means that shall most certainly secure primary union we avoid some of these dangers, but not all of them; as evidenced by the fact that, even when all these means have been employed, secondary hæmorrhage does sometimes take place. I believe this bleeding occurs because, either with the intention of the operator or unavoidably and against his will, the ligature cuts through the two inner arterial coats and may produce ulceration of the outer one,¹ or even if the outer coat preserve its continuity, being now exposed unsupported to the whole force of the blood-stream, it may expand into an aneurism at the seat of ligature.²

A few years ago, I asked myself whether the organisable or soluble ligature would permit us with safety to dispense with the division of the inner arterial tunics, this dangerous

¹ See Mr. Bryant's cases, 'Clin. Soc. Trans.,' vol. xi, p. 1. Mr. MacCarthy's case and Mr. G. G. Heath's (Newcastle) case, 'Lancet,' vol. i, 1877.

² Mr. T. Smith's case, 'Clin. Soc. Trans.,' vol. xi, p. 52.

element in deligation, and on the 10th December, 1878, when I brought to the notice of this Society three cases of double distal ligature for innominate aneurism, I alluded at some length to this subject, rather with the view of eliciting opinions, than of establishing a practice. I confess to a feeling of surprise on finding that two surgeons whose names are well known in connection with aneurism, still adhere to the view that organisable ligatures should be tied so as to divide the coats of the vessels, thus, exposing patients to those great dangers which I have just shown to be inseparable from such practice. Probably a belief, perfectly well founded, in the unreliability of catgut, and a feeling that it is very difficult to tie that material tight enough to be firm, yet loose enough to leave intact the vascular coats, lie at the root of these opinions. Nevertheless, it is simply obvious, that if we had a material possessing a fixed rate of organisation, which would not divide the arterial coats, we could cast around the vessel a permanent band, that should effectually stop circulation in the artery, yet leave its walls entire and hæmorrhage-proof.

The unreliable nature of catgut lies in the fact that under like conditions its conduct is various; we cannot tell what any specimen will do; nay, different parts of the same cord will act differently. One piece of the material will be dissolved in from forty-eight to sixty hours; another is found entire after a fortnight. Sometimes, though rarely, a piece is not absorbed at all, sometimes it seems to divide all the arterial coats very quickly; in other instances it pierces a hole in them. At first I was inclined to attribute this untrustiness to the varying periods, during which the catgut was kept in antiseptic oil, and I used to carbolise my own ligatures with somewhat better, but still imperfect result. I then inquired into the process of the first manufacture, the making of catgut itself. I believe it is from these processes, that the unreliable nature of our antiseptic ligatures is derived. The following is slightly abbreviated from Chambers' Cyclopædia. "Catgut is made from the intestines of sheep, rarely from those of horses, mules, or asses, never from

cats. After cleaning the parts from feculent and other impurities, detaching mesenteric fat &c., the gut is steeped in water for several days, until the external membrane (probably the peritoneum) can be scraped off with a blunt knife. After another process of soaking and scraping, the small intestines are separated from the large. These latter are used for other purposes, while the former are returned to a solution of potash, carbonate of potash and a little alum, they are lastly drawn through a perforated brass thimble and assorted into their various sizes. They are then subjected to the fumes of burning sulphur, which acts as an antiseptic and arrests decomposition.

After reading this and observing that putrefaction in water plays a large part in the manufacture of catgut, I no longer wondered at its variability; for it surely must happen that one piece, even one part of a cord must have been, previous to fumigation, more rotten and putrescent than another.

But even this was to my mind less cause of objection to catgut as a ligature in continuity than the form of the material. I felt that a round cord could hardly be relied upon not to cut arterial coats, and I was determined that my ligature should be flat, a form with which I found by experiment arterial coats cannot be divided. Many materials were thought of, a good number made the subject of experiment; but all rejected until the idea occurred to me that the most fitting substance with which to surround an artery would be arterial tissue. I procured with some difficulty the aorta of some oxen in a perfectly fresh state, and placed them in a three per cent. solution of carbolic acid. Without troubling the Society with a description of my failures I may say that after a little time I succeeded in separating the middle from the outer coat, and, by cutting the former spirally round and round, in procuring flat tape-like ligatures or bands of much more than the requisite length. But such a ligature is, though very strong, much too elastic to bear a reliable knot. This superfluous elasticity can be removed by suspending the cord and hanging on it a weight of from one to three pounds (according to the breadth, &c., of the piece) so as to stretch it to at

least an additional half of its length ; a piece of six feet should stretch to nine, of four feet to six, and so on. Thus treated, the material dries into a horny or vellum-like substance, which I store in antiseptic gauze, and place ten minutes before use in carbolic solution when it again becomes extremely soft and pliable. Some experiments were tried, not on the human body, whereby I found that on the thirteenth day after burying a piece of this middle coat about $1\frac{1}{2}$ inch square between the abdominal muscles and skin, the material was still *in situ* and but little changed ; it was living ; it had, as it were, simply come to life. Some other issues were also tried, which for obvious reasons I cannot now describe. I then tested the security of the knot, and its power of resisting an expansile force, by stretching a tolerably thick india-rubber cord until it was quite thin and tying two ligatures tightly round it. The diameter of the tied portions was measured and the cord released ; the constricted parts had but very slightly dilated. The cord was then cut between the two ties, one portion placed in glycerine, the other allowed to dry. On the fourth day the wet one had perhaps a little increased in diameter, the dry one had plainly diminished, facts attributable to the soaking and desiccation respectively. The knots had not yielded in the least ; it ought perhaps to be said that I think the security of the knots depends upon considerable tightness of its second part or involution—for this material when pulled upon gets narrower and when released resumes its former breadth ; the broadened part forming a sort of buttress against the tie of the narrowed portion entirely prevents slipping.

My last experiment was the case just narrated, which indeed chanced to form the meeting point of two enterprises ; it has by furnishing proof of the first mentioned views enabled me, I think, to educe correct indications for tying one or the other set of vessels in different forms of aortic aneurism, whereby a precision hitherto wanting will have been imparted to our practice. Also although one case cannot prove invariable success, it has enabled me to introduce a ligature whose

mode of occluding the vessel is such that it will, I trust, eliminate from this branch of surgery secondary hæmorrhage at the place of deligation, even when such arteries as the first part of the subclavian or the innominate are tied. If this be so, and the view is not I believe too sanguine, a wider field will have been opened to surgery and a high degree of safety conferred on a number of operations, which hitherto have proved all but uniformly fatal.