An account of some experiments illustrative of the mode of formation of the dissecting aneurisms / by Thomas B. Peacock.

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Peacock, Thomas B. 1812-1882.
University of Glasgow. Library

Publication/Creation

[London] : [J. Masters, Printers], [1843]

Persistent URL

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Dr. J. H. Bennett
with T. W. Peacock's
Kind Regards.

(5)

ARTICLE II.—*An Account of some Experiments illustrative of the mode of formation of the Dissecting Aneurisms. By* THOMAS B. PEACOCK, M.D., *late Pathologist to the Edinburgh Royal Infirmary.* (With a Plate.)

[EXTRACTED FROM THE LONDON AND EDINBURGH MONTHLY JOURNAL OF MEDICAL SCIENCE, FOR OCTOBER, MDCCCXLIII.]

IT has been usually conceived, that the Dissecting Aneurisms derive their origin from the occurrence of a rupture of the internal coats of an artery, by which the blood is enabled to insinuate itself between the external and middle coats and effect their separation, so as to produce a sac following the course of the vessel; and the development of this form of disease, rather than the circumscribed aneurismal tumours, has been explained by supposing that, in the latter cases, the slow change, on which the internal rupture depends, has previously rendered the tunics intimately adherent, so as to preclude their separation by the current of blood.

To this view it has, however, been objected,—*first*, That the existence of adhesions between the coats, in cases of circumscribed aneurismal tumours, so far from being constant, is of rare occurrence; *secondly*, That "the supposition of such adhesion is unnecessary, and is discountenanced by the intimate and firm union which generally exists between the coats of an artery, and by the effect of forcibly injecting fluids either directly between the coats, or into an artery until its internal coats are ruptured, when, in either case, a tumour results from the elevation and distension of the outer coat, and not an extensive separation of the coats as in a dissecting aneurism."[1] The latter objection, which has recently been urged by Professor Henderson, is, I conceive, founded on the experiments of Drs. Nicholls and Scarpa. The former is said to have demonstrated before the Royal Society, in the year 1728,[2] that when air is blown into the pulmonary artery until the internal coat be ruptured, "the external will form itself into aneurismal tumours." Scarpa

[1] MONTHLY JOURNAL for July 1843. [2] Phil. Trans. 1728.

states that he had frequently repeated the experiment of Nicholls with a similar result. He remarks, "if leaving the aorta in its place as well as the viscera near it, a little air or any other fluid be injected by a small hole made artificially between the cellular covering and the subjacent muscular or proper fibrous coat of the artery, the matter injected raises and elevates into a tumour the cellular membrane which closely embraces the artery, without properly destroying its cells, which it fills and distends in a remarkable manner. If the matter injected be capable of coagulating, such as melted wax, and if it be pushed with much force, it is observed that the cellular sheath of the artery is not only raised over it like a tumour, by the impetus of the injection, but the internal cells of that covering are also lacerated, and on examining afterwards the capsule of the artificial tumour, it appears as if it were formed of several layers, rough and irregular internally, smooth and polished externally. The same thing happens if air be pushed with much force, or any liquid substance capable of coagulating within the artery, so that by the excess of the impulsion, the proper or internal muscular coats burst at some point of their circumference, in which experiment, as in the first, the cellular sheath of the artery is observed to be raised, after the manner of a tumour in aneurism."[1] Burns, on the other hand, speaking of experiments performed on the arteries after death, says, "we find that they rather militate against the doctrine of aneurism being dependent on the forcing of the blood among the cells of the external covering of the artery. Take an artery whose internal coats are diseased, ossified or cartilaginous for example, and whose external covering is healthy, and inject wax into it, and observe what happens; you will see, that at first the injection is confined to the proper canal of the vessel, but that by distending this the internal coats rupture, when immediately the wax penetrates between the cellular coat and the one next it, separating the one from the other to a great extent. The wax is never collected in a circumscribed cyst, as the blood is in aneurism; on the contrary, it is diffused over a great extent of the artery, and it even compresses the internal coats, pushing them sometimes so much as almost to obliterate the canal of the vessel. In aneurism, we never find this diffusion of the blood."[2]

Such being the different results obtained by eminent observers, I have been induced to try the following experiments with the view of ascertaining the effect of injecting fluids into the vessels.

In the first three experiments the fluid was injected between the external and middle coats.

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[1] Scarpa on Aneurisms, translated by Wishart, 1808, p. 70.

[2] Burns on Diseases of the Heart, p. 211, 1809.

1st. The aorta of a young man, 23 years of age, who died of phthisis, was cut across at its point of passage from the chest; the internal coats of the vessel were then divided near its lower extremity, and a ligature applied round the branches passing to the head and neck, and at the root of the aorta, and a pipe inserted at the lower extremity of the vessel. On injecting water from an eight oz. syringe, the vessel became distended, and the fluid then insinuated itself between the coats, separating and distending them as far as the subclavian artery; beyond this the separation could not be continued, in consequence of the fluid freely escaping by the small rupture which had been occasioned in removing the lungs from the chest. The laceration of the middle and internal tunics extended nearly around the whole circumference of the vessel, and was occasioned by the application of a tight ligature.

2nd. The thoracic aorta of a girl, 13 years of age, who had died of scarlet fever, having been slit open at its lower extremity, a pipe was inserted, and the vessels passing to the head and neck and the origin of the aorta, secured. Fluid was then injected with great force, so as to distend the vessel, without, however, any rupture of the coats taking place. The vessel was then removed from the body and a pipe inserted at the root of the arteria innominata, the ligature at the origin of the aorta being retained, and a fissure made in the internal coats with the scissors. The fluid injected passed readily into the cellular tissue external to the middle coat, distending the external layer of condensed tissue with its covering of pericardium to a great extent, and escaping partly by transudation through these membranes and partly into the adjacent cellular tissue. The perforation of the internal coats was, in this instance, about a quarter of an inch in length.

3rd. The pipe was fixed in the ascending aorta of a man, 30 years of age, who died of lumbar abscess, and a ligature was placed around the origin of the vessel; an incision was made with a sharp knife in the internal coats of the vessel, extending across about half an inch of its circumference, and penetrating entirely the middle coat at one point. Fluid being injected, the external coat and attached pericardium were elevated and distended over the whole of the ascending aorta, and by continuing the pressure, these membranes gave way, and the fluid escaped. On examination, no separation of the layers of the middle coat, along the line of incision, had taken place, and the perforation by which the fluid had passed beneath the external coat was found to be a mere puncture.

In each of these cases, having ascertained the effects of injecting the fluid into the canal of the vessel after the whole of the middle coat was entirely divided, I placed the mouth-piece of

the syringe between the laminæ of the middle coat, and thus readily separated them to an indefinite extent. The two remaining experiments were directed to ascertaining the effect of a laceration of a part only of the middle coat.

4th. The aorta of a female, aged 30, who died of pneumonia attended with a copious purperous eruption on the skin, having been removed from the body, an incision was made by a sharp knife through the internal and a portion of the middle coat, about one inch and a half in length, and extending partly in a transverse and partly in a longitudinal direction ;—this incision occupied the convexity of the arch, and was situated at about a third of the distance between the arteria innominata and the origin of the aorta. A pipe was then secured immediately behind the left subclavian artery, and a ligature passed tightly around the base of the heart, and the vessels arising from the arch. On injecting fluid, so as to distend the aorta, little or no effect was at first produced on the coats, a portion only of the upper edge of the fissure being turned back ; on making, however, a very slight separation of the edges, and continuing the pressure steadily but without great force, the fluid passed between the laminæ of the middle coat, and then burst through the outer layer of that tunic and its covering of the cellular coat and pericardium. On removing the pipe and slitting up the vessel behind, the separation of the lower edge of the fissure was found to have taken place only at the transverse portion, and the dissection of the laminæ of the middle coat extended along the anterior surface of the vessel as far as its origin, forming a sac about one inch in width. The layer of middle coat forming the external boundary of the separated portion, and the corresponding cellular coat and pericardium, had given way transversely.

5th. The aorta of a female about 60 years of age, who had died of acute cerebral disease, was cut across as it passed between the crura of the diaphragm, and a large pipe inserted into its thoracic extremity, the vessels passing to the neck and upper extremity, and the aorta at its origin, being at the same time secured by ligatures. The vessel was then distended by a powerful injection syringe ; notwithstanding, however, the employment of strong pressure, its coats continued entire, and at length several of the small branches having ruptured, the fluid seemed to escape almost as readily as it could be thrown in. The pipe was then removed, and the finger being introduced into the lower extremity of the vessel, a laceration of the internal coats was produced by the nail. On the injection being again tried, the fluid at first distended the vessel moderately, and then readily passed beneath the external coat, producing great distension over its whole extent. The vessel being removed and examined, the laceration was found to be situated in the centre

of the descending aorta and to occupy about a third of its circumference. From this point, the fluid had effected a separation between the coats, extending above to the ligature at the origin of the aorta, and downwards to the attachment of the tube; the separation occupying, however, not the space between the external and middle coats, but the laminæ of the latter. Around the fissure, the portion of the middle coat separated in connection with the external tunic, was extremely thin; but, in advancing towards the anterior portion of the vessel, it gradually increased in thickness, being in the ascending aorta about half a French line in width. The origins of the intercostal arteries were in several instances torn across by the pressure of the extravasated fluid, and thus these vessels seemed to open into the newly-formed canal. The separation of the coats advanced about three-fourths of an inch along the left subclavian artery, and the internal coats being there again ruptured, the sac re-opened into the canal of that vessel. At the origin of the left carotid and arteria innominata, the same rupture and recommunication had taken place. The separation of the coats occupied, at its posterior extremity, about two-thirds of the circumference of the vessel, being apparently bounded by the points of departure of the intercostal arteries; while in the ascending and transverse portions of the arch, the separation was seated only at the front of the vessel: in the left subclavian, the whole circle of the vessel was exposed.

In all these cases, the vessels experimented upon presented no signs of disease; and, as each of the observations has been repeated in various ways with analogous results, so that the whole number of observations amounts to fifteen or sixteen, we are, I think, justified in drawing the following conclusions from them.

I. That the coats of the aorta in a healthy state cannot be ruptured by the application of any ordinary force from within. In this respect the result of these experiments corresponds with some of those made by Dr. Davy. In attempting to produce rupture of the internal coats by the finger introduced into the vessel, I have often been struck with the extreme amount of force required. In one instance, after pressing forcibly against the coats of the descending portion of the thoracic aorta, they were felt to give way, and it was supposed, as the finger allowed of being readily pushed outward so as to distend the external tunic, that the internal coat had been ruptured. On injecting fluid into the artery, no separation of the coats was, however, produced, and this was explained by finding, when the vessel was slit up, that the internal coat was only abraded but not ruptured, while the fibres of the middle coat had separated transversely, so as to allow the finger to be pushed between them;—thus verifying the assertion, that the internal coat admits of a

kind of hernia through the fibres of the middle coat, as in cases described by Laennec, and of which specimens have occurred to Dubois, Dupuytren, and Liston. [1]

II. That when the internal coats are entirely divided, the fluid injected into the vessel readily penetrates the cellular tissue between the middle and external coat, distends the latter for a great distance along the course of the vessel, and never forms a tumour bearing any resemblance to a circumbscribed aneurism. This effect is equally produced whether the aperture be of considerable extent or a mere puncture.

III. That the external coat alone does not in these cases possess sufficient power to resist permanently the pressure of the extravasated fluid, which therefore escapes into the adjacent texture either by transudation or rupture.

IV. That when the middle coat is partially divided, its different layers admit of being separated by the current of fluid over a greater or less extent; but that the canal thus formed, except in the portion of aorta covered by the pericardium, tends rather to reopen into the original vessel, than to burst externally.

V. That this separation between the laminæ of the middle coat is less readily effected than the diffusion of the fluid beneath the external coat; to accomplish that purpose, it being necessary that the fissure should follow a transverse direction, so as to be opposed to the course of the injected fluid, and its edges to be separated, so that the current may bear directly upon the outer laminæ.

In several instances experiments have been performed upon the aorta after portions of the internal and middle coats have been scooped out with a sharp knife. On free distension of the vessel by a column of water, no separation of the layers of the middle coat was, however, effected, nor was any bulging of the side of the vessel corresponding to the removed portions apparent, yet it seems probable that a swelling analogous to a circumscribed aneurism would be produced by the pressure, if sufficiently long continued. It also appears from the greater elasticity of the middle coat of the pulmonary artery, than of that of the aorta, that fluids injected between its laminæ, do not readily effect an extensive separation, but that the coats rather admit of being elevated into a tumour. It is therefore probable, from the circumstance of Dr. Nicholls' experiments having been performed on the pulmonary artery, that this may have led to the results which he obtained. It might also be objected to some of the experiments of Scarpa, that no inference drawn from the results of inflating the vessels with air, can be made to apply to the explanation of the effects

[1] Dictionnaire de Médecine, &c., art. Anévrisme; and Cooper's First Lines of Surgery, 1836.

which would attend the extravasation between the coats, of an incompressible fluid like the blood.

The application of the above experiments to the explanation of the mode of formation of dissecting aneurisms is obvious :—

I. It would naturally be supposed that in most cases of the disease, the arterial tunics would present decided proofs of diseased lacerability. This condition was noticed by Dr. Paterson in the specimen of the disease which he exhibited to the Anatomical Society during the last session, and occurred also in several of the cases on record; while in others, as in one of those examined at the Infirmary, the same state of parts was shown by the presence of two or more ruptures in different portions of the affected vessel. In a third class of cases, the occurrence of the ruptures while the patient was in a state of rest, and when no cause existed for any increased impetus in the circulation, equally evince the diseased condition of the vessel.

II. It would also be inferred, as the external coat alone does not appear capable of retaining the column of extravasated fluid, while the middle coat readily admits of separation, that the sac of the dissecting aneurism would be more likely to be situated between the laminæ of the middle tunic, than, as has been usually supposed, in the space between the external and middle coat. This inference is supported by the fact, that in the three cases which I have personally examined in the recent state, including the case of which Dr. Henderson has recorded the particulars, the separation was found to have taken place between the laminæ of the middle coat, and Drs. Pennock and Goddard made the same observations in cases they have related in the *American Journal of Medical Sciences*.

III. The fifth experiment would appear to show, that provided the middle coat be only partially ruptured, its different layers would readily admit of separation, by the action of the circulating fluid; this cannot, however, always be the case, since from numerous trials I am satisfied, that in a healthy artery, it is only when the fissure affords a direct opposition to the current that a separation is effected. There have also occurred cases in which the internal coats of the aorta have been ruptured during life, yet in which no extensive extravasation between the coats had taken place. A preparation of this kind, taken from the body of a man who died seven weeks after sustaining a fracture of the spine by a fall, is contained in the museum of Guy's Hospital; a transverse rupture of the internal coats extends across one-third of the circumference of the ascending aorta, yet the edges of the fissure, though widely apart, have been very slightly separated from the tissues beneath, and lymph having been effused around the lacerated portion, the formation of a circumscribed aneurismal sac has commenced. It is therefore most probable that a dissecting aneurism can only take place in

arteries of which the coats are, as suggested by Dr. Henderson, rendered more readily separable by disease; and unquestionably, such a condition of the coats as he observed, in which "the outer coat, with an adherent lamina of the middle, admitted of being detached with a facility not much less than that with which two moistened pieces of paper may be separated,"[1] must have greatly aided in the development of the disease. The greater or less readiness with which the coats admit of separation in different cases is also attested by the very varied extent of detachment in different instances. Thus, in one of the cases which occurred at the Infirmary, the coats were separated from the commencement of the abdominal aorta to the heart, yet little doubt could exist that death must have ensued very rapidly on the occurrence of the internal rupture; on the other hand, in a case in a soldier at Chatham, the symptoms indicated the occurrence of the internal rupture three days before death, yet on examination, the sac which originated from the ascending aorta was found to be only two inches in extent.

Along with this paper is published a drawing of a preparation of the parts in the fifth experiment. Those who have seen the preparation in the University Museum of the first case of Dissecting Aneurism which occurred at the Infirmary, and of which an account and drawing will be published in the October Number of the *Edinburgh Medical and Surgical Journal*, will be at once struck with the close resemblance between the two.

DESCRIPTION OF THE PLATE.

a, The point at which the ligature was applied around the origin of the aorta.

b, The lower extremity of the descending aorta, into which the interjection-pipe was inserted.

c, The fissure produced by the nail extending through the internal, and a portion of the middle coat, and by which the fluid escaped from the canal of the vessel between the laminæ of the middle coat.

ddd, The outer tunic, with a thin layer of the middle coat which was detached from the internal by the extravasated fluid, turned back so as to show the separation extending from the point at which the pipe was applied, to the ligature on the origin of the aorta.

e, The portion of the middle and the external coat, forming the boundary of the vessel, slit open from the point at which the pipe was applied to near the origin of the left subclavian artery.

The separation is seen to advance some distance along the left subclavian artery, while it terminates at the commencement of the art. innominata and left carotid.

[1] Ed. and Lond. Medical Journal, August, 1842.

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