FURTHER INVESTIGATIONS ON THE STRUCTURE AND THE ENDINGS OF THE NERVUS DEPRESSOR IN MAN

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As far as I was capable of surveying the literature recently only A. Ábrahám (1949) has dealt with the shapes and connective conditions of the terminations of the depressor in man. He established that the human aorta arch contains specific sensory end-organs attached by the means of large neurofibrillary end-plates to the wall of the aorta. This paper discusses and describes in detail further examinations of these end-organs.

Material and Method.

The investigations were carried out on the aorta arches of individuals of different age and sex. Among others the aorta arches of the following persons were examined: of a girl aged 2 months and of women aged 40, 52, 54, 56, 66, 68, 73, furthermore those of men aged 35, 48, 60 and 65. The material was fixed in formalin. Frozen sections were made and impregnated by the method of Bielschowsky and subsequently treated with gold chloride.

Histological Observations.

In the aorta arch of man, particulary in the section where the truncus brachio-cephalicus arises a fairly well limited sensory area can be found, in which besides numerous sympathetic fibres also nerve trunks consisting of thick myelinated fibres with a thick axon run. (Fig. 1.) In some parts the nerves cover the sensory area to such an extent that at times it resembles a nerve tissue. Often these trunks proceed together to the border of the adventitia in close proximity, on entering it their fibres immediately begin to diverge and presently the nerve gradually loosens. Later the fibres diverge far apart, arborise richly, actually interweaving the adventitia. (Fig. 2.) In the external layer of the adventitia the thick trunks consisting of thick myelinated fibres spreading very abundantly over the upper and side wall of the arch can be easily distinguished from the thin sympathetic fibres proceeding along the rich capillary plexuses.

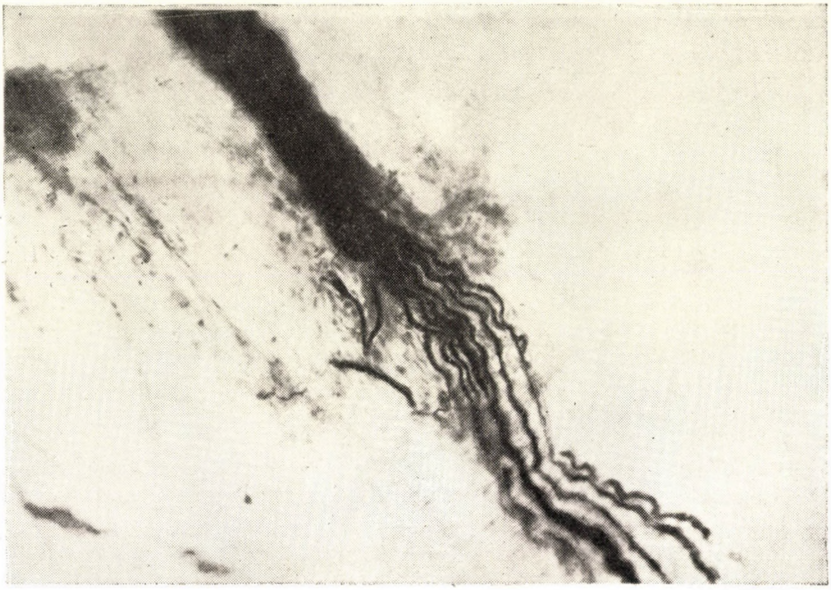

Figure 1. Homo : Nerve — trunk and nerve — endings from the wall of the arcus aortae. Bielschowsky method. Photomicrograph x 200.

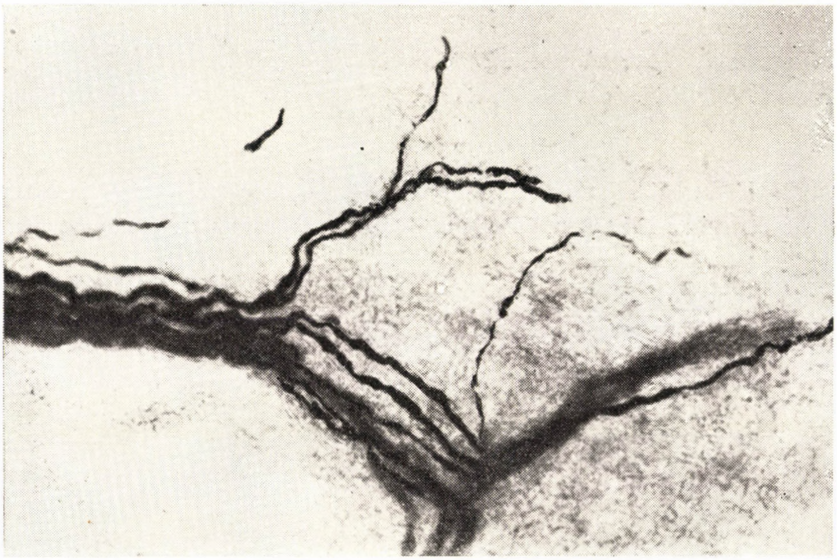

Figure 2. Homo : Nerve-fibre from the wall of the arcus aortae. Bielschowsky method. Photomicrograph x 200.

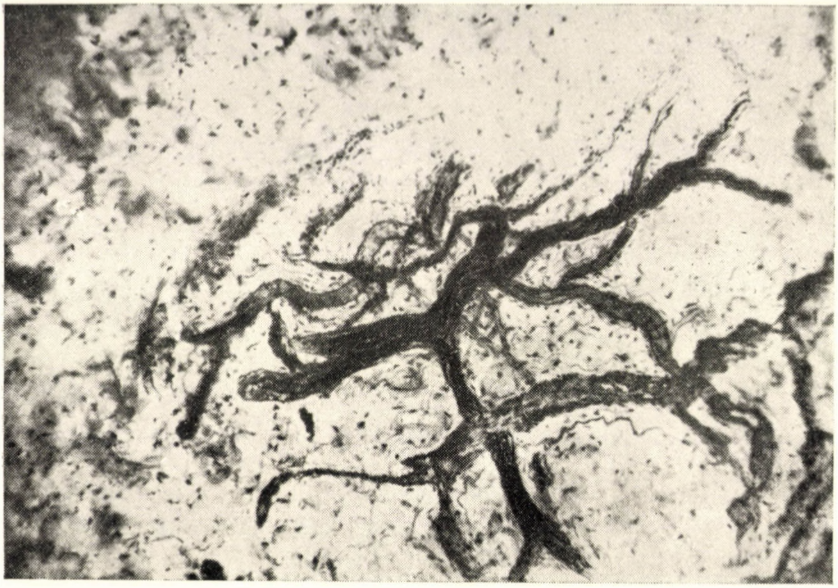

Figure 3. Homo : Arcus aortae : Innervation of the adventitia. Bielschowsky method. Photomicrograph x 80.

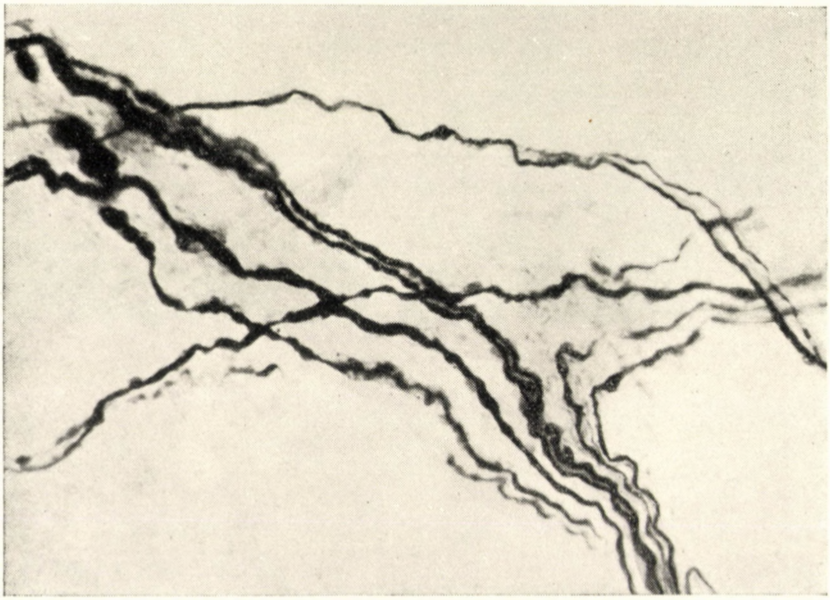

Figure 4. Homo : Nerve-fibres from the wall of the arcus aortae. Bielschowsky method. Photomicrograph x 200.

(Fig. 3.) The fibres themselves are very characteristic, and can be very well distinguished from the sympathetic fibres, the more so since they demonstrate the peculiar and characteristic shape of the fibres of the vagus. (Fig. 4.)

The thick fibres running towards the internal boundary of the adventitia start to give off their abundant branches about at the middle of the adventitia area. The arborization, resp. the gradual divergence continues till the internal boundary of the adventitia where the branching shows an unusual, in respect to the receptors of the bloodvessels most particularly characteristic form and extent. (Fig. 5.) The fibres first divide dichotomically and subsequently the arborization becomes so abundant and exceptional that it can hardly be described, the more so since the following figure exhibits it in an adequate manner (Fig. 6.). A particular and at the same time characteristic feature of these fibres is that the fibres arising from the branching of the main fibre are in most cases thicker than the original fibre from which they derive. These secondary, strikingly thickening, strongly varicose fibres thicken still to a great extent

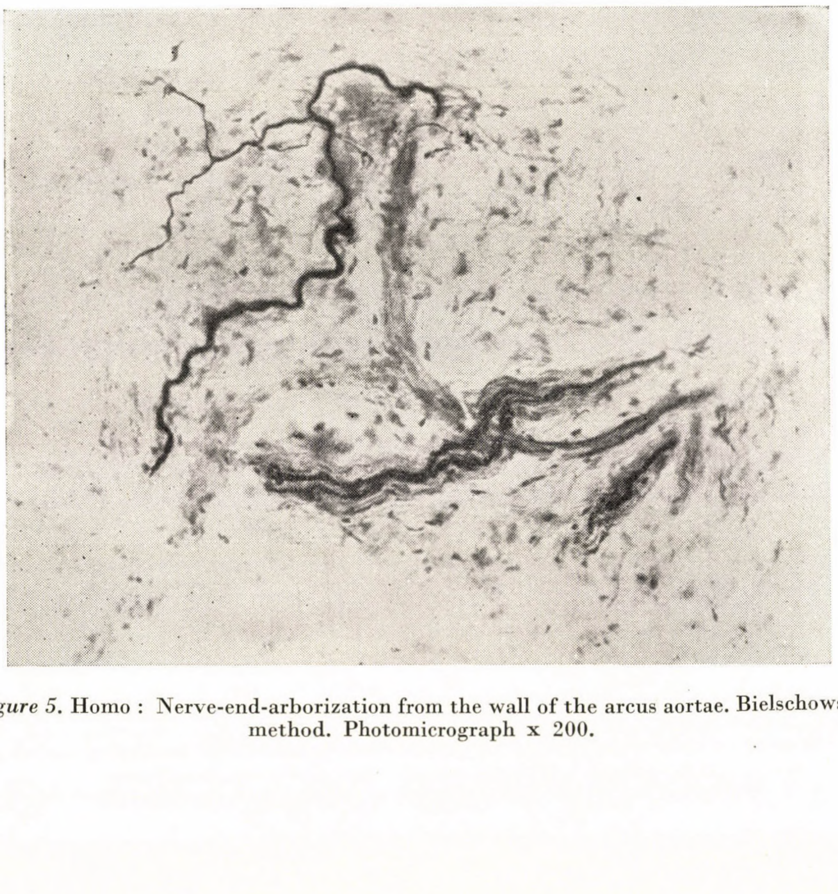

Figure 5. Homo : Nerve-end-arborization from the wall of the arcus aortae. Bielschowsky method. Photomicrograph x 200.

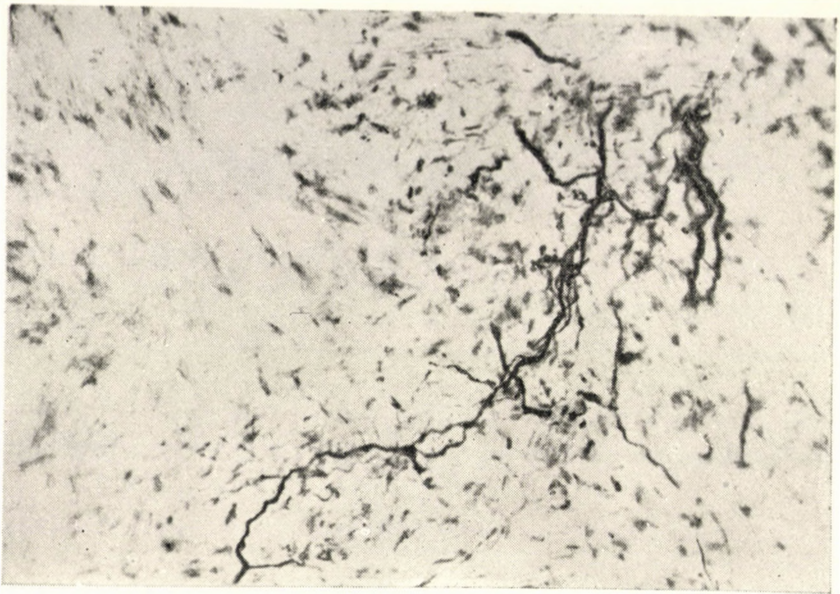

Figure 6. Homo : Nerve-end-arborization from the wall of the arcus aortae. Bielschowsky method. Photomicrograph x 200.

before starting their terminal ramification, interweave many times composing loops presently to proceed into very delicate end-fibres which run for a long distance and end in the interior border of the adventitia in most distinctly limited neurofibrillary end-plates with a very lucid structure. Also in the case of a single branch system these structures are highly characteristic and exhibit most various shapes and systems. (Fig. 7.)

Not unfrequently, although they do not belong to the common ones, nerve-pictures can be detected in which three or four nerve fibres of the same nervetrunk, after having gradually lost their neurilemmas and myelin sheaths, proceed into a very intensive, but loosely structured end-coil, the ultraterminal fibres of which are attached to the connective tissue of the adventitia by means of most varying neurofibrillary plexuses The fibres emerging from the nervetrunk in a big arch adopt a waved course on which their varices are strikingly large. The neurofibrils can also be distinctly detected along the greater part of their course. Fibres of a fibre of similar structure proceed from the opposite direction and form on intermingling with the former ones a loose coil in which they retain their independence, their endings also covering a separate area. Howover, ultimately we are after all dealing with a very extensive uni-

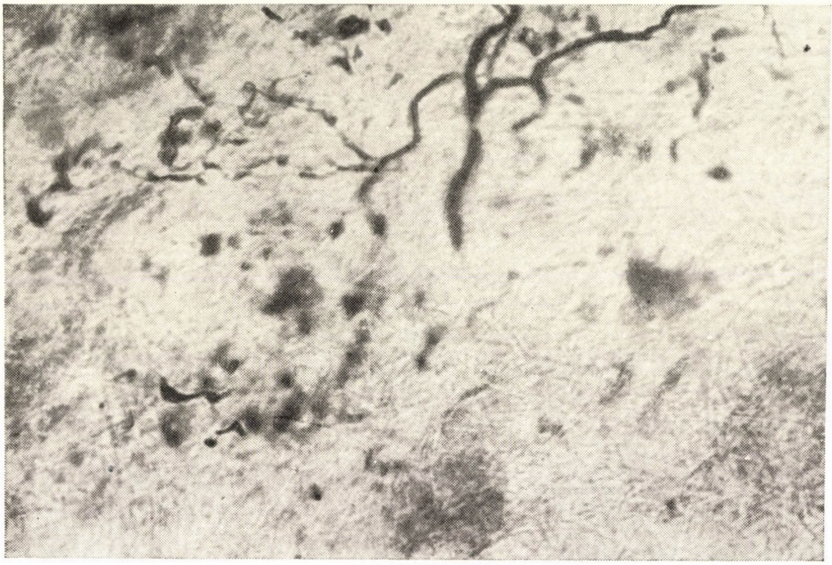

Figure 7. Homo : Nerve-end-arborization and end-plates from the wall of the arcus aortae. Bielschowsky method. Photomicropraph x 500.

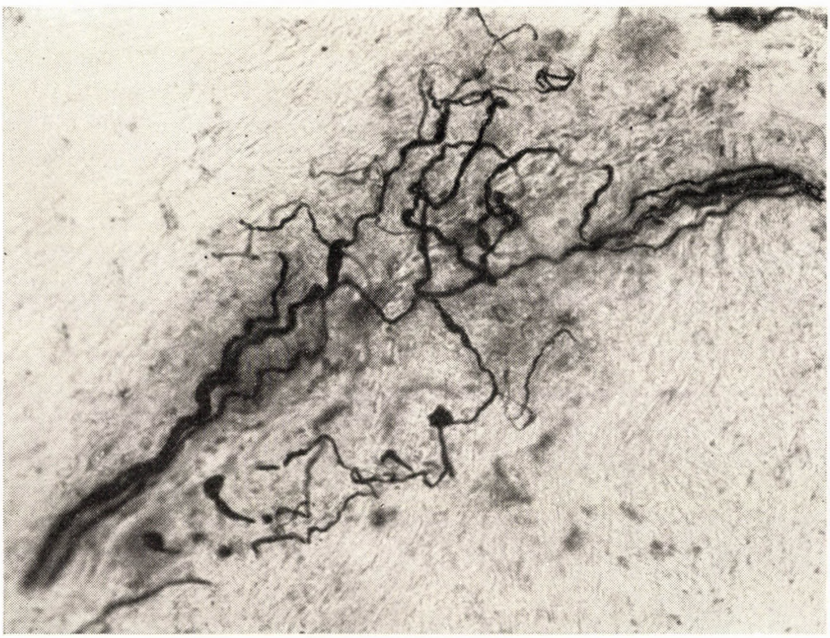

Figure 8. Homo : End-organ from the wall of the arcus aortae. Bielschowsky method. Photomicrograph x 200.

tary loose coil which can be termed an end-organ and which taking its structure and extremely delicate and close connexions with the connective tissue into account, must be considered to be one of the characteristic receptor forms of the aorta arch. A pecularity of the coil described above is that it contains a most strikingly large polyedric varix exhibiting, owing to the distinctly limited fibres emerging from it, the characteristic features of a nerve cell. However, this peculiar formation is after all no nerve cell, because it has no nucleus and no nucleolus. (Fig. 8.)

The arborization of the single receptor is generally very rich and in most cases quite peculiar. Sometimes a single main fibre may also exhibit most distinctly the limiting sheaths and gives off quite delicate branches which divide many times, tapering suddenly at different places, proceeding presently into very delicate neurofibrillary end-plexuses or end-nets, respectively. It is interesting to note that in the course of the very fine fibres neurofibrillary nets of various shapes and extention occur too agreeing in shape as well as in structure completely with the end-plates. (Fig. 9.)

The collaterals arising in the main fibre ramify sometimes so abundantly that someone who has not seen the preparations might easily assume that the figures demonstrating these pictures represent reproductions of several combined sections. However, this is not the case. The walls of the bloodvessels, particularly those of the sinus caroticus and the aorta arch are most suitable for a thorough study of the rich arborizations involving one single section only. This can be explained by the fact of the end-systems of the receptors being exclusively restricted to the adventitia of the aorta and sinus caroticus and even there only to the internal boundary area extending towards the media. Thus if we succeed in completely smoothing out the wall of the vessel and in cutting the section in its plane from within towards the exterior, or vice versa, exactly uniformly, and furthermore in impregnating the sections perfectly we obtain a section showing the entire branch system of a smaller nerve or nerve fibre with all its endings exhibiting the system as a whole. (Fig. 10.) A nerve picture like the one shown on Fig 10. is so elective, lucid, and perfect that every specialist in this branch of science is convinced at first sight that the wall of the arteries is probably the only organ of the human body in which the receptors are attached so abundantly, delicately, closely and on so large an area to the stimuli receiving and transmitting organ. To be able to interpret still more precisely the connexions and end-formations — if this is altogether possible — end-systems in which the end-plates are still larger, more striking and numerous were examined under very high

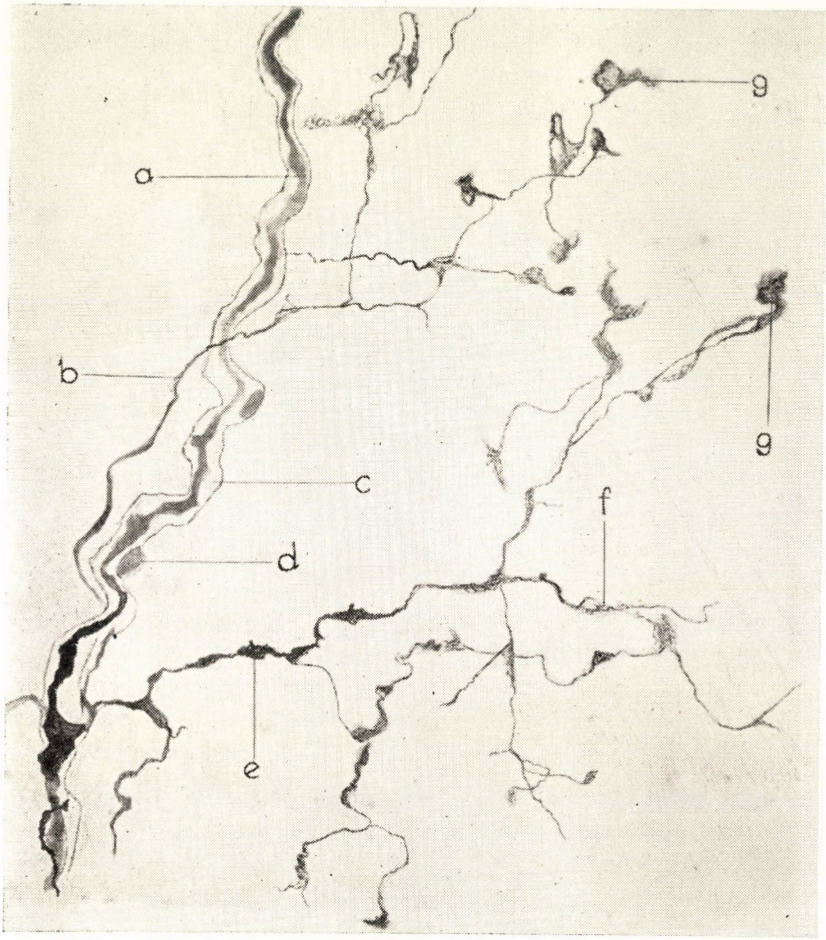

Figure 9. Homo : Nerve-end-arborization from the wall of the arcus aortae. Bielschowsky method. a. main fibre, *b)* collateral, *c)* myelin sheath, *d)* neurilemma, *e)* varix, *f)* neurofibrills, *g)* end-plate. Microscopically x 900 magnified, photographically diminished to the ½.

power magnification. These end-systems involving numerous end-plates appear to compose at the boundary of the media and adventitia a true neurofibrillary veil drawing each point of this layer into its operational circle. Of course, as can be seen from the investigations, *this does not* really occur, however, the end-plates lying over, beside and under each other are so numerous that they compose, also in the case of a complete lack of correlation, a most remarkable physiological unity.

The dominating character of this physiological unity is still more remarkable if the endings of a single delicate end-fibre are examined under very high power magnification. Owing to the largeness of the end-plates and the excellent visibility of the neurofibrillary nets, on examination under high power magnification, this figure exhibits still better

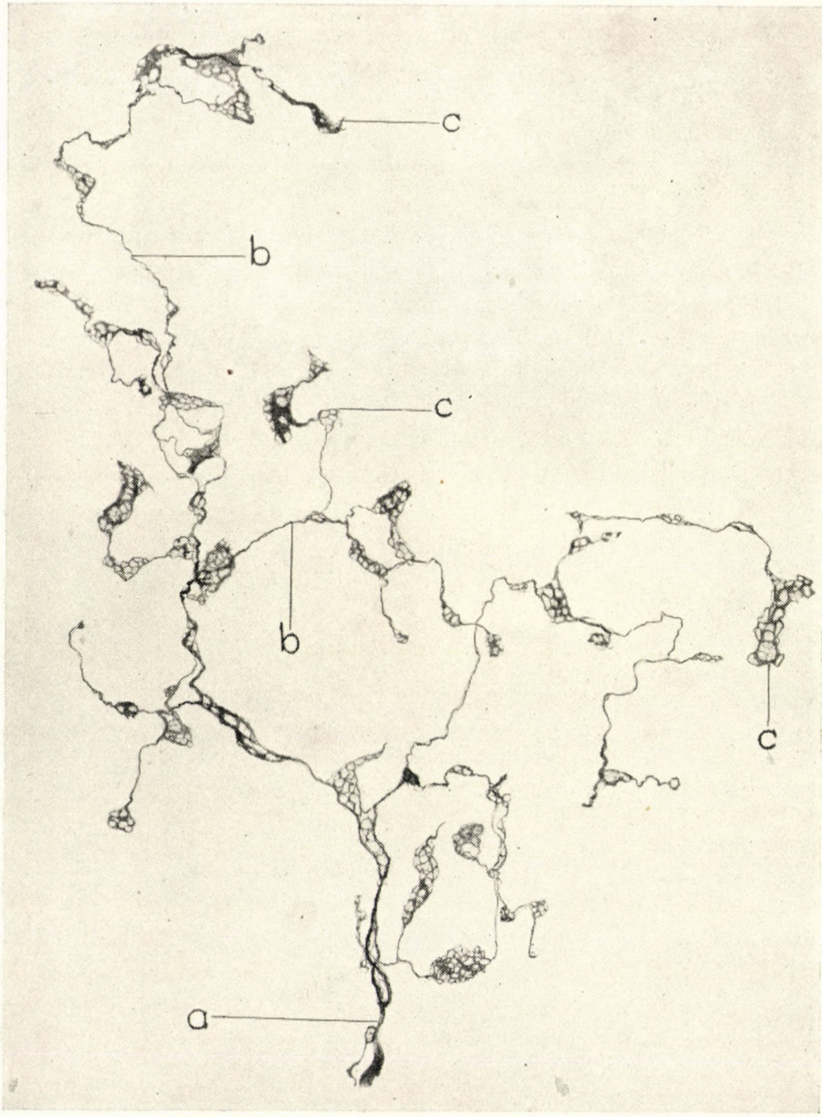

Figure 10. Homo : Nerve-end-arborization from the wall of the arcus aortae. Bielschowsky method *a)* collateral, *b)* end-fibre, *c)* end-plate. Microscopically ú 1350 magnified photographically diminished to the ½.

than the previous ones the close connexion between the receptor endings and the host tissue. Such pictures prove in a most convincing manner that there hardly can be any other area of the peripherical nerve system in which the close connexion between the host tissue and the nerve system is so obvious. The numerousness and delicacy of the neurofibrillary plates and end-plates which are inserted into these extremely delicate branches reflects most truly the important and exceedingly sensitive physiological role accomplished by these endings as receptor organs. (Fig. 11.) This fine, but most clear neurohistological picture interprets the important part allotted to the receptors and through them to the nervus depressor in the regulating of the blood pressure, which task they perform together with the sympathetic system from second to second achieving the utmost possible limit of sensitiveness.

The aforementioned pictures and other similar ones, which are not unfrequent in the sections prepared from the walls of the aorta appear to demonstrate the complete fusion of the neurofibrils and the fibrils of the connective tissue. However, this is only apparently the case, as a thorough microscopic examination shows beyond doubt that even the single neurofibrils are also distinctly limited towards the fibres of the

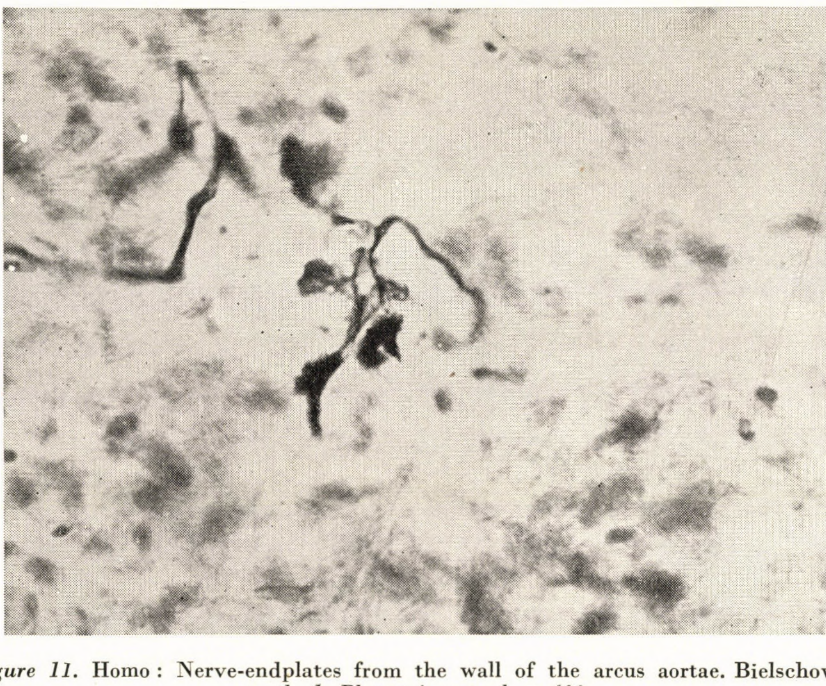

Figure 11. Homo : Nerve-endplates from the wall of the arcus aortae. Bielschowsky method. Photomicrograph x 600.

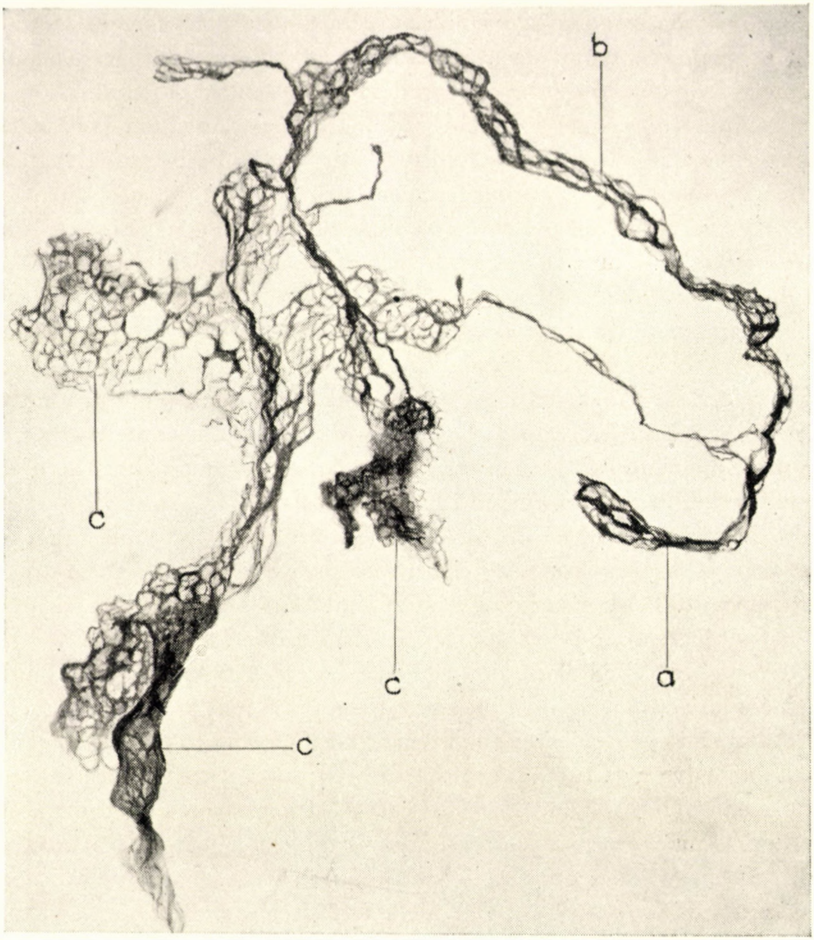

Figure 12. Homo : Nerve-endplates from the wall of the arcus aortae. Bielschowsky method. *a)* end-fibre, *b)* neurofibrils, *c)* endplates. Microscopically x 2400 magnified, photographically diminished to the $^2/_3$

connective tissue. Nevertheless, it can be undoubtedly stated — and this is so obvios on the figures that it needs no further explanation — that there extends on the ends of all of the very delicate nerve fibres a comparitively large meshed neurofibrillary lattice, the gaps of which are filled up by the connective tissue, the fibrils of the lattice covering the connective tissue. Thus the close connexion is evident and the blood pressure inhibitory role of the receptors functioning as sensitive receptor apparatus clear. (Fig. 12.)[1]

[1]) Figure 12 represents the drawing of the same nerve end-plates which can be seen on the photomicrograph 11.

So far, the important branch system of the receptors of the aorta arch, the various ways of its attachment to the connective tissue and its extremely delicate endings have been demonstrated, there remain, however, still two important questions to settle. The first question is : whether or not the described receptors really belong to the end-branch system of the nervus depressor. Considering the structure of the aforementioned branch systems and receptors, as well as the physiological results already known since a long time this must be answered in the affirmative, although according to Eberhart—Koch »Beim Menschen bisher über den Verlauf der Aortennervenfasern noch wenig bekannt«.

The second question is to locate the exact histological position of the receptors described above. Köstler and Tschermak (1902) found that the myelinated fibres enter at certain points into the media and lose their myelin sheaths there. From this fact they assumed that the demyelinated fibres run further and end in the intima, which is really the place at which the receptors end. »Diese Vermutung bedarf indessen um so mehr noch des Beweises, als die Pressoreceptoren im Sinus Caroticus sicher nur in der Adventitia zu finden sind« can be read in Koch's book on this subject. And truly Koch's doubts proved to be justified. The precedingly described examinations evidenced beyond doubt that the receptores are situated in the adventitia only and nowhere else. The myelinated fibres never enter the media, but on losing their myelin sheaths all end exclusively in the adventitia, directly in the area where the latter is attached to the media. Therefore it is of course out of the question that the intima contains receptors. Such is the exact histological situation, which in the author's opinion is quite suffcient and suitable to enable the receptors to respond by the means of their abundant and very extended neurofibrillary plate-system to every internal and external pressure and for them to widen or narrow, according to the just at the moment prevailing requirement, the lumen of the vessel by connecting reflectorically the sympathetic fibre system of the media. Consequently the task of the nervus depressor is not to cause the sinking of the blood pressure like its name denotes, but to inhibit the blood pressure, hence it is no more termed »depressor« but aorta nerve — ramus aorticus vagi — by the more recent literature.

SUMMARY

1. The nervus depressor consists of strikingly thick *myelinated* fibres which after entering the aorta arch proceed in several bundles into the adventita. In most cases the bundles contain very delicate smoothe edged thin fibres too, which on the base of their structure must be considered to derive from the sympathetic system. The latter run to the surface layers of the media.

2. The fibres of the depressor bundles already diverge at the median area of the adventitia, occasionally crossing one another and after diverging strongly turn to the other side of the nerve, commencing their abundant arborization towards the internal border of the connective tissue.

3. The side branches are characterized by their sudden tapering after ramification, subsequent thickening and proceeding in the shape of most delicate branches with large varices to the internal border of the adventitia in which they terminate.

4. As contrasted with the statements of Köster and Tschermak it could be established that the fibres exclusively end in the adventitia. Not a single myelinated fibre enters the media, thus neither the media nor the intima contain receptors.

5. The endings of the fibres, contrary to other sensory nerve terminations, are very extensive neurofibrillary plates the shapes of which very a great deal and are very characteristic.

6. The neurofibrils are very distinctly visible in the plates and compose an actual neurofibrillary lattice, the meshwork of which mostly shows quite peculiar shapes.

7. Since the depressor bundles are numerous, and the single bundles contain many thick fibres, the fibres of which fall into rich endbranch systems each ending in a large leaf-like neurofibrillary plate, an almost veil-like neurofibrillary layer extends over the internal border of the adventitia of the aorta. This veli-like neurofibrillary end-system explains the two depressor reflexes already observed by Ludwig and Cyon, as well as the sinking of the blood pressure and the simultaneous decrease of the heart beats.

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ДАЛЬНЕЙШИЕ ИССЛЕДОВАНИЯ ПО СТРУКТУРЕ И ОКОНЧАНИЯМ „NERVUS DEPRESSOR“

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(Р е з ю м е)

1. Нерв депрессор (»Nervus depressor«) состоит из весьма толстых миэлиновых волокон, которые, после вступления в дугу аорты, несколькими пучками попадают в adventitia. В большинстве случаев пучки также содержат очень мелкие, гладко окаймленные, тонкие волокна и на основании их структуры, следует считать, что они происходят из симпатичной системы. Они идут к верхним слоям Media.

2. Волокна пучков депрессора расходятся уже в медиальной области adventitia, иногда перекрещиваясь друг с другом, а после сильного расхождения изгибаются на другую сторону нерва и одновременно начинается их изобильное древовидное разветвление по направлению внутренних границ соединительных тканей.

3. Боковые разветвления характеризируются внезапным заострением после разветвления, последующим утолщением и тем, что они, в виде особенно тонких ветвей с большими узлами, следуют в внутренней грани adventitia, где они кончаются.

4. В противоположность утверждениям Кэстера и Чермак, можно было установить, что волокна кончаются исключительно в adventitia. Ни единое миэлиновое волокно не достигает Media, вследствие чего, ни Media, ни Intima, не содержат рецепторов.

5. Концы волокон, в совершенной противоположности с оконечностями концам други сензорных нервов, являются очень рапростертыми неврофиброзными пластинками, формы которых сильно разновидны и очень характерны.

6. Нервные волокна можно ясно видеть на пластинках, где они образуют вид решетки нервных волокон, сплетение которой часто показывает совершенно особые формы.

7. В виду того, что пучки депрессора многочисленны и отдельные пучки содержат много толстых волокон, волокна которых распадаются на очень богатую систему конечного разветвления, из которых каждая кончается широкой листовидной неврофиброзной пластинкой, над внутренней гранью adventitia аорты, распространяется почти вуалеобразный слой нервных волокон. Эта вуалеобразная нервлофиброзная конечная система разъясняет те два рефлекса депрессора, которые уже заметили Людвиг и Цион, как и понижение кровяного давления и одновременное уменьшение сердцебиений.