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ON THE BLOOD SUPPLY OF THE NERVES OF THE UPPER EXTREMITY

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The vessels of the nerves of the upper extremity have so far not been worked out in detail. It was the aim of our investigations to obtain more detailed knowledge concerning the macro- and microscopy of these nerve-vessels.

The vascular supply of the nerves of the lower extremity had been worked out by us previously. The present work represents a supplement to the study that dealt with the nerve-vessels of the lower extremity and this way we are able to give a detailed picture of the vascular supply of the nerves of the extremities. These nerves are not infrequently subject to surgical or clinical interference.

In our investigations we utilized the same technique that had been used in connection with tke lower extremity, i. e. we used injected specimens. We have injected partly rubber solved in diluted ammonia, to which various stains could be mixed, partly 50 per cent china ink. The rubber solution proved to be very adequate for macroscopical demonstration of vessels, because vessels filled up witk rubber can be prepared easily. Tke china ink injection, on the other hand, is a means by which microscopical details of the nerve vessels can be readily demonstrated. Finally, in order to complete our investigations, x-ray contrast medium injections were made; x-ray films made of these preparates show with distinction the distribution of the nerve vessels.

Results of the Investigations

1. Initial portion of the brachial plexus

Injection of this area is rendered difficult by the constrictung effect of the hiatus scaleni. Each of the five maior nerves : n. radialis, axillaris, musculocutaneus, medianus and ulnaris receives a strong vessel from the surrounding area. The first vessels can be seen immediately at the site where they leave the foramina intervertebralia. These vessels originate from the posterior spinal arteries localised here. The vascular supply of the primary bundles is poorer than that of the secondary ones.

2. The sub-clavicular portion of the brachial plexus

It is in the subclavicular portion of the brachial plexus that the vascular supply of the plexus is the richest. From one of the direct muscle branches of the

axillary artery a nerve vessel trunk originates that gives off broom-like branches. The branches of this trunk penetrate into the bundels to form their central vessels. In one or another of these nerves the vessel does run in the centre of the nerve, but can be found on the surface of these nerves in a longer part. This

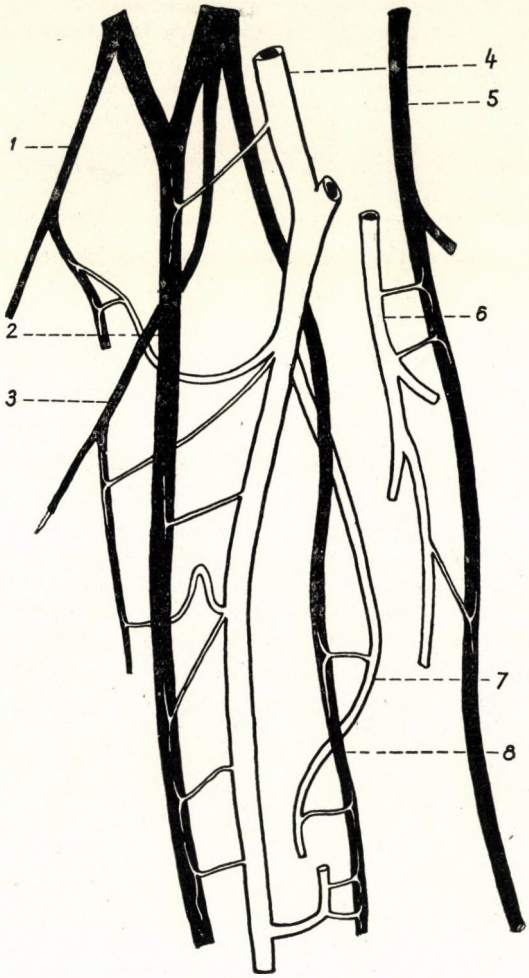

Fig. 1.
Secondary bundles of the brachial plexus

1. N. musculocutaneus
2. N. medianus
3. N. cutaneus brachii medialis
4. N. akillaris
5. N. radialis
6. A. profunda brachii
7. A. collateralis ulnaris superior
8. N. ulnaris

can be seen in the ulnar nerve, in the initial portion of the radial nerve and in that portion of the median nerve that comes after the two roots. As illustrated in Fig. 1., the n. musculocutaneus and the broom-like branches of the mentioned

trunk of the axillary artery. The initial portion of the n. medianus is supplied by the branches of the axillary artery that follow each other in segments. The initial portion of the radial nerve, on the other hand, receives branches from the a. profunda brachii.

a) *Nervus medianus*

In the median nerve a very marked vascular network is visible even to the naked eye. The vascular trunk running to the upper portion, as it has been

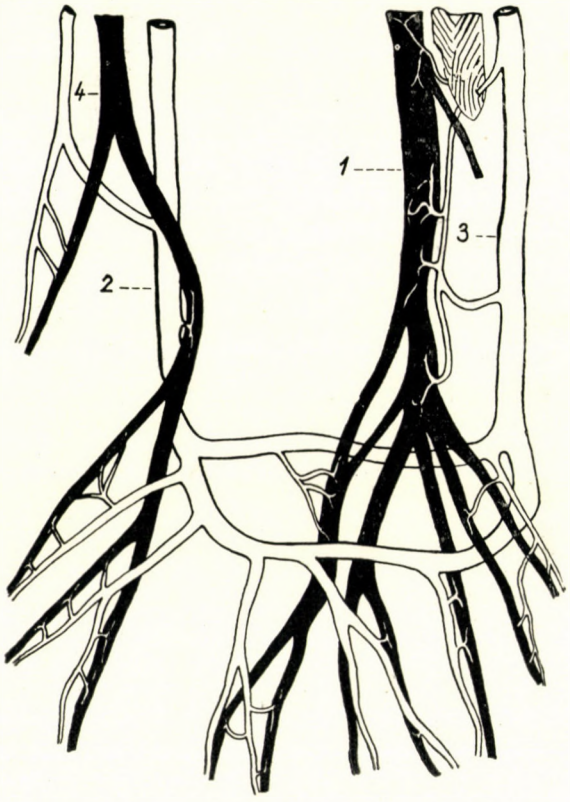

Fig. 2.
Vessels of the nerves of the palm
2. N. ulnaris
1. N. medianus
4. N. ulnaris
3. A. radialis

mentioned already, originates from a thicker muscle branch of the axillary artery that goes directly to the flexors of the upper arm. Having penetrated, it is divided into ascending and descending branches, which, continuing their course, form a strong, continuous central vessel. Collateral vessels originating from this central trunk communicate with each other and from a network.

To the middle portion of the median nerve in the upper arm the brachial artery supplies several smaller arteries. These smaller arteries in general do not communicate with each other.

In the fossa cubiti the median nerve collects its vascular supply from three sources. One branch comes from one of the muscle branches of the brachial artery, two from the a. recurrens ulnaris. Although the collaterals are marked, the vessels originating from different segments usually do not reach each other.

In the forearm, within the distracted bundles of the median nerve a rich, irregular vascular net can be demonstrated that is supplied by one or two thicker vessels originating from the radial artery. The rich vascularization of the lower end of the median nerve should also be mentioned (Fig. 2.).

In the palmer region the nutritive vessels of the median nerve originate from the palmer arch, resp. from the ramus volaris superficialis of the radial artery. The four parallel vessels corresponding to the fibres communicate with each other at two sites by means of connective transverse branches and thus a fenestrated vascular system is formed. (Fig. 2.)

On histological examination of unstained, injected preparates of 400—500 microns thicknes, several major vascular trunks are revealed in central position. These trunks can be sen between the compartements of the endoneurium or at their periphery. In stained preparates it can be demonstrated that the vessels run parallel with the nerve fibres. A considerably high number of vessels can be observed in the nerve.

b) *Nervus radialis*

To the upper section of this nerve branches usually come from that runk that originates from the axillary artery and gives broom-like branches to the median. ulnar, musculocutaneus, cutaneus antebrachii medialis nerves. Distally from this area the radial nerve gets its vascular supply from the a. profunda brachii, which, having reached the nerve substance, is divided into typical ascending and descending branches. These branches usually take a central course and to not communicate with each other. From among the cutaneous branches of the radial nerve it is only the n. cutaneus antebrachii dorsalis that contains a demonstrable vessel in its lower part. This vessel originates from the brachial artery, is superficial in position, but within a short distance it assumes a perforating form. Its tiny branches run to the loose connective tissue of the surrounding area.

In the cubital region the radial nerve gets its branches from the a. collateralis ulnaris superior, as well as from the a. collateralis ulnaris inferior. These branches supply the nerve according to the ascending and descending types.

In the forearm the radial nerve is supplied by branches originating from the trunk of the radial artery (r. superficialis), while the ramus profundus of the nerve is supplied partly by the a. radialis, partly by the a. interossea dorsalis.

It should be mentioned that the superficial branch of the radial nerve has a relatively poor vascular supply.

On the radial side of the dorsal part of the hand the branches of the ramus superficialis that supply the fingers run parallel with the aa. metacarpae dorsales originating from the radial artery. In areas where the nerve and the artery run close to each other, the arteries give off branches segmentally. These branches resemble in their distribution the teeth of a comb ; they penetrate into the nerve and are continued within its substance in the from of ascending and descending rami. In the nerve they occupy a central position. In the dorsal region of the

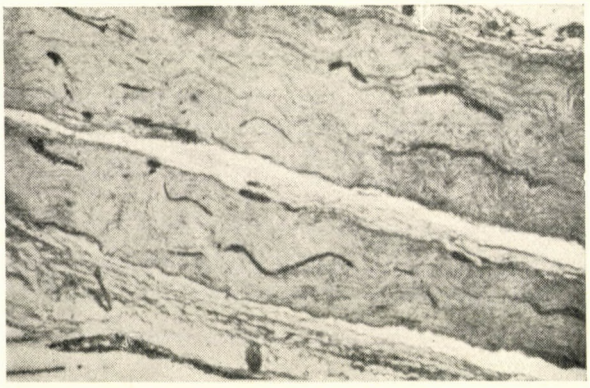

Fig. 3.
N. radialis, china ink injection, longitudinal section

hand it is again the already mentioned vessels in connection with the loose connective tissue that supply the nerve.

Histological examination reveals that in the trunk of the nerve partly in central position, partly peripherally between the endoneurium compartments large vessels can be demonstrated. The nerve fibre bundles themselves are considerably rich in vessels. In longitudinal sections several contorted vessels can be seen, the majority of which runs parallel with the fibres of the nerves. (Fig. 3.)

c) *Nervus ulnaris*

In the upper portion of the ulnar nerve the upper part of the trunk of the nerve is rather poorly supplied with vessels, while in its lower part it is richly vascularized. The uppermost vessel originates directly from the a. axillaris and supplies the nerve along a distance of about 10 cm. After a practically unsupplied area comes the dense vascular net of the lower portion. The three arteries leading to this part of the nerve are distributed over areas of equal size. The upper two thirds of the network is supplied by two vessels originating from the a. collateralis ulnaris superior. To the lower one-third the a. recurrens ulnaris gives

a double branch of which the proximal is stronger. The first branch, originating from the a. collateralis ulnaris superior is continued in a thick and long ascending central vessel, its descending ramus is, however, thin and short. It is the second branch that contributes the majority of vessels to the rich vascular net demonstrable in this from below, from the stronger branch of the double vessel originating from the a. recurrens ulnaris. Summing up we may say that it is the cubital region-part of the ulnar nerve that has the best vascular supply.

The forearm-portion of the ulnar nerve receives supply from 6 to 7 arterial branches. In this area we can see two unusual types of distribution. In the most proximal part of the nerve we can frequently find a thick muscle artery bridging over the nerve ; at the point where the artery is in contact with the nerve, it sends a small ascending and a descending vessel into the substance of the nerve. Thus the vessel leading to the nerve is missing, though we have been meeting it in all former instances. Another interesting fact is that in the lower two-thirds of the nerve one of the vessels leading to it gives off — after having penetrated into the substance of the nerve — double ascending and descending branches. We have also observed that in certain areas, in which the nerves are exposed to a greater number of injuries, the vascular supply the nerves receive is also denser. This part of the nerve is to be found in the area approximately corresponding to that between the lig. carpi volare and lig. carpi transversum. A similar dense vascular network is demonstrable in the median nerve in its part lying at about the same height. The rest of the vessels supplying the ulnar nerve divide according to the characteristic ascending and descending types. All nutritive arteries of the part situated in the forearm region are supplied by the ulnar artery.

In the volar region it is the ulnar artery that supplies branches for the nutrition of the nerve. The lower part of this section is more richly vascularized, as it gets nutritive vessels also from the ramus profundus of the ulnar artery. The rami of the fingers receive vessels from the rami digitales of the ulnar artery (Fig. 2.). The majority of these small vessels terminates in the surrounding loose fibrous connective tissue. The aa. metacarpales dorsales also send vessels to these branches of the nerve.

Histological investigations reveal that on the injected cross section of the ulnar nerve a remarkably great number of vessel-sections can be seen. In the centre large vascular trunks can be demonstrated. In addition, in the spaces of the endoneurium several maior vessels can be seen. In longitudinal sections wavy vessels can be seen, running parallel with the fibres.

d) *Nervus musculocutaneus*

This nerve receives 2 to 3 branches from the a. axillaris. The first branch originates from the vascular trunk of the axillary artery that has broom-like

rami and that has been mentioned already in connection with the other branches of the brancial plexus.

The vascularization of this nerve is remarkably poor as compared to that of the former nerves.

e) *Nervus axillaris*

Several arteries contribute branches to the vascular supply of this nerve. Some of these vessels originate from the vascular trunk leading to the upper part of the radial nerve. In accordance with this fact, the uppermost part of the radial nerve has a richer vascularization. The rest of the vessels originates partly from the brachial artery, partly, — in the lateral axillary space — from the a. circumflexa humeri.

f) *Nervus cutaneus antebrachii medialis*

This nerve has a vascular supply characteristic in general of vascular conditions prevailing in thinner nerves. Fine branches are contributed to this nerve by vessels running parallel with, crossing over or penetrating into the substance of the nerve. In certain areas, on the other hand, as a consequence of vessels that lead to the nerve, divide into ascending and descending rami, then take a central position within its substance, it is the type of vascularization characteristic of nerves of medium thicknes that perdominates. In the upperarm it is the a. axillaris resp. the a. brachialis, in the forearm the a ulnaris that supply branches to this nerve. (Fig. 1.) In the ramus volaris about 8 to 9, in the ramus ulnaris about 5 branches are disributed over or are seen to penetrate into the nerve.

Conclusions

Studying the vascular supply of the nerves in the upper extremity we have arrived at the conclusion that those general observations we had described connection with the vasa nervorum in the lower extremity are applicable to these structures in the upper extremity as well. Therefore it seems probable that the vascular structure of the peripheral nervous system of the body has the same general characteristics.

In analogy with what we demonstrated in connection with the nerves of the lower extremity, in the upper limb we could find in typical cases vessel leading to a nerve of the thicker type, that penetrated into the substance of the nerve and there, dividing into an ascending and a descending branch, formed a strong central vessel. The central vessels running toward each other, in order to assure blood supply in the whole cross section of the nerve, show a distribution belonging to the ascending-descending, fork-like or to the broom-like type. Anastomosis exists between the central vessels ; though injection was not completely uccessful, this was not quite obvious macroscopically. The net formation is also

typical ; its density varies in different regions. — Vascular supply in the thinner nerves is characterised by the arterial net that may be found on their surface or may perforate their substance several times, by the diagonal division, by the ascending branch, by the absence of a major vessel leading to them, as well as by the superficial position of the central vessel. Also here it could be demonstrated that the nerves have a segmented vascular supply. This segmentation is demonstrable at the origin as well as at the division in the nerve substance of the vessels, inasmuch as it is always a certain segment of the nerve that is supplied by an individual vessel after it penetrated into the substance of that nerve.

No definite types could be set up in connection vith the veins of the nerves of the upper extremity. The veins of the nerves have the same irregular course as can be seen in any other part of the body. Interwining, formation of plexus formation of nets by individual trunks are the characteristic features these veins exhibit, with the exception of the concomittant double veins and other instances in connection with vhich this could not be observed.

When studying vasa vasorum, it will be found invariably that in certain areas there is considerably richer vascular supply. The median nerve e. g. is very strongly supplied in the canalis carpi and in its part situated distally from this region. The vessels of the tibial nerve are found to be the most marked in the sulcus retromalleolaris. On comparing several preparates the same results have been found. In general it can be stated that in areas in which the nerve is exposed to mere intensive mechanical insults, the vascular supply is better. — In the Cubital region the ulnar nerve is not only in a superficial position but it is also in this region that it is exposed to different insults. If we consider in addition, that on flexion and extension it becomes relaxed or streched, it is quite obvious that in this region better developed vascular system is needed for the maintenance of unimpaired circulation. Most probably the situation is the same in the aforementioned parts of the median or tibial nerves.

Summary

The vascular supply of the nerves of the upper extermity has been studied by means of rubber solution and china ink injection. This represents a continuation of our work dealing with the vasa nervorum in the lower limb.

Similar to what we have seen in connection with the nerves of the lower extremity, the thicker nerve trunks in the upper extremity (nn. medianus, ulnaris, radialis etc.) have vascularisation belonging to the ascending-descending type, while the thinner ones (n. cutaneus antebrachii medialis, the thinner branches of the radial nerve etc.) receive a vascular supply characterised by several perforating vessels.

Histological examinations reveal that, just as it was the case in the lower extremity, the vessels are to be found in the compartments of the endoneurium. In nerves having a larger diameter one, occasionally more, central major vessel can be demonstrated.

As regards topography it can be stated that the vascular supply to the nerves of the upper extremity comes from several vessels or from various branches of the same vessel and is segmented in type. In certain areas more frequently exposed to mechanical affects the blood supply is found to be richer.

REFERENCES

Anderle, H. : (1914.) Zur Lehre von der Querschnittopographie der Nerven an der oberen Extremität. Ztschr. f. Angew. Anatomie und Konstitutionslehre. I.

Bartholdy : (1897.) Die Arterien der Nerven. Morphologische Arbeiten von G. Schwalbe. II.

Dünning, H. S.—Wolff, H. G. : (1937.) The relative vascularity of various parts of the central and peripheral nervous system of the cat and its relation to function. Journal of Comp. Neurol. Vol. 67. 433—450.

Perria, L. : (1940.) Sull'angioarchitettonica dei nervi spinali. Riv. Pat. Nerv. 55. 406—429.

Szabó Z. — Bölönyi F. : (1951) Tke blood supply of the nerves in the lower. extremity. Acta Morphologica. T. I Fasc. 3.

КРОВОСНАБЖЕНИЕ НЕРВОВ ВЕРХНЕЙ КОНЕЧНОСТИ

З. Сабо и Ф. Бэлэньи

Р е з ю м е

На основе инъекционных исследований, проведенных резиновым раствором и тушью, авторы, в дополнение к своим уже раньше опубликованным исследованиям кровоснабжения нервов нижней конечности, изучали кровоснабжение нервов верхней конечности.

Подобно нервам нижней конечности, более крупные стволы (n. medianus, n. radialis, n. ulnaris) располагают сосудами как восходящего, так и нисходящего типа, а в то же время более тонкие нервы (n. cutaneus antibrachii medialis, тонкие ветви лучевого нерва и т. д.) имеют сосуды перекалывающего типа.

Гистологические исследования показывают, что на подобие нижней конечности, сосуды верхней конечности располагаются в щелях, ограниченных эндоневрием. В более крупных нервах имеются по одному более крупному центральному сосуду, а иногда и больше.

С топографической точки зрения можно установить, что кровоснабжение нервов верхней конечности происходит по участкам из некоторых сосудов или же из некоторых ветвей одного и того-же сосуда. В отдельных местах, подверженных более частым механическим воздействиям, кровоснабжение является более богатым.