THE DISTRIBUTION OF NERVES TO THE ARTERIES OF THE ARM

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WITH A DISCUSSION OF THE CLINICAL VALUE OF RESULTS

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FIVE FIGURES

I. INTRODUCTION

Our knowledge concerning the vascular nerves of the body is exceedingly scanty. The standard textbooks contain only scattered and incomplete references to the nerve-supply of bloodvessels. The few isolated papers dealing with the subject are inadequate and do not give clear accounts which can be utilized in clinical practice. For these reasons Mr. Wingate Todd has advised the reinvestigation of the vascular nerves in homo and at his suggestion I have undertaken the dissection of the nerve-supply to the arteries in the arm. The importance of the work was first impressed on Mr. Todd by Prof. Elliot Smith of Manchester, whose description of a vascular nerve to the axillary artery formed the starting point of the present research and to which reference will be made later.

The following is a brief abstract of the statements made in various standard textbooks regarding the nerve-supply of the bloodvessels of the arm:

Hamann, writing in Piersol's Anatomy (1), mentions (a) the supply of fibers to the subclavian artery and its branches from the ansa subclavia (p. 1362), the distribution of filaments (b) to the volar interosseous artery from the corresponding nerve (p. 1301) and (c) to the ulnar artery in the forearm from the palmar cutaneous branch of the ulnar nerve (p. 1305).

Paterson in Cunningham's Textbook, (2) refers to the branch supplied by the musculo-cutaneous nerve to the brachial artery (p. 705) and mentions the first and third groups of filaments in Hamann's description.

In Quain's textbook Symington (3) describes, in addition to those mentioned by Hamann, a branch from the musculo-cutaneous nerve to the brachial artery (p. 75). The irregularity in precise origin of this nerve is indicated by the fact that it was found by Testut coming from the branch to the M. brachialis.

The textbooks known as Morris' (4) and Gray's (5) Anatomies do not give any further information regarding the vascular nerves of the arm.

Rauber's textbook also was consulted without obtaining further information (6).

Soulié's description in Poirier's treatise (7) mentions the distribution of filaments (a) to the brachial artery from the median nerve (p. 907), (b) to the volar ulnar recurrent artery from the volar interosseous nerve near its origin (p. 908), (c) to the ulnar artery in the forearm from the palmar cutaneous branch of the ulnar nerve (p. 919), and (d) to the radial artery and vein from the volar terminal branch of the musculo-cutaneous nerve. He also describes the direct supply of filaments to the subclavian artery and its branches from the inferior cervical ganglion (p. 1094).

From the preceding abstract it is clear that the references scattered through the various descriptions are by no means connected or complete.

While one expects variations to be found in the origin of supply from the sympathetic chain to the subclavian artery, one would like to know whether the same irregularity is to be encountered in the nerve-supply to the other arteries of the arm.

The fact that Elliot Smith describes a nerve twig, arising from the lateral anterior thoracic nerve, to the axillary artery in a case exhibiting multiple anomalies of nerves (8), illustrates the contention that variation is to be noticed among vascular nerves as among nerves to muscle and skin. It is, of course, plain from the outset that the view that the sympathetic vascular nerves pass along the main blood channels to their distribution on the peripheral vessels, is quite inaccurate. This view and the evidence for its refutation have already been discussed by Mr. Todd (9), hence I may, without further delay, set down my own observations on the vascular nerves of the arm.

II. PERSONAL OBSERVATIONS

The dissections were made on six upper limbs. Five of these came from cadavera in the Anatomical Department. One hand and forearm was obtained from Dr. Hamann's operating theatre. This last was dissected within a day or so of amputation in order to confirm the observations made on the cadavera. It may be well to remark at this stage that the dissection of nerves to bloodvessels is much easier on freshly obtained material and also that the embalming of the subject with more than a small percentage of formalin renders difficult the identification of these small nerves from bundles of fascia or connective tissue. The nerves mentioned in this paper were readily identifiable by the naked eye, all doubtful filaments being rejected. As the work progressed it became plain that the recording of every individual nerve filament is impossible and also that there is considerable variation in the exact site of origin of the filament from the nerve and in the situation where it reaches the artery in different arms. That is, the sympathetic fibers to the vessels of the limb are as erratic in their precise origin and distribution as are those in the trunk.

The subclavian and proximal part of the axillary arteries receive a nerve-supply directly from the sympathetic chain, between or including the middle and inferior cervical ganglia. In the specimens I have examined, the nerve was moderate in size and reached the artery on its inferior aspect, proximal to the passage of the vessel over the first rib. It accompanied the artery in the interval between the M. scalenus anterior and the bone (fig. 1). The portion of the subclavian artery immediately adjacent to its origin was supplied by twigs from the ansa subclavia. I did not find further branches of supply to the axillary artery from the lateral anterior cutaneous nerve (see Elliot Smith '95). The brachial artery was supplied by a varying number of twigs from the musculo-cutaneous nerve. In one case, I met with an example of high division of the brachial artery, which is depicted in figure 2. The nerve-supply in the illustration differs in no essential point from that of normal brachial arteries.

Fig. 1 Right subclavian artery, to show nerve-supply. In this case the comparatively large filament arose by two roots from the inferior cervical ganglion and the sympathetic chain immediately above.

Fig. 2 Diagram of nerve-supply to the brachial artery. This example showed high division of the vessel, but illustrates as well as a normal specimen the supply from the musculo-cutaneous nerve. Note that the same nerve supplies an additional branch to the proximal part of the radial artery.

Each figure represents an individual instance, but may be taken as a fairly typical illustration of the general plan of vascular nerves. The illustrations are reduced to one-fourth normal size.

The radial artery, as can be seen from figure 3 received a nerve-supply from the superficial ramus of the radial nerve. The dorsal carpal arch and its branches also received twigs from this nerve (fig. 5).

Fig. 3 Diagram to illustrate the nerve-supply to the radial and ulnar arteries and to the superficial volar arch. The radial artery, though sometimes receiving a branch from the musculo-cutaneous nerve, obtains branches from the superficial terminal ramus of the radial nerve. The ulnar nerve supplies its companion artery by twigs from its main trunk and from its palmar cutaneous branch. The complicated supply from median and ulnar nerves to the superficial volar arch and digital vessels is also shown.

It is to be remembered that, as in figure 2, the radial artery near its origin may receive a branch from the musculo-cutaneous nerve.

The ulnar artery obtained its supply from the ulnar nerve in the forearm, several twigs arising from the palmar cutaneous branch (fig. 3).

The superficial volar arch and the digital vessels received a complicated supply from the median and ulnar nerves (fig. 3).

It will be observed that the distribution of nerves to vessels corresponds fairly exactly with the nerve-supply to the skin of the fingers. Also there is a much more plentiful supply of twigs to the vessels in the more distal parts of the limb.

Fig. 4 Diagram of the branches of the ramus profundus of the ulnar nerve to the deep volar arch.

The deep volar arch and its branches received their supply from the deep branch of the ulnar nerve (fig. 4).

The portion of the dorsal carpal arch associated with the little and ring fingers was supplied by the dorsal cutaneous branch of the ulnar nerve but the major portion of the arch, as already mentioned, received its supply from the superficial ramus of the radial nerve (fig. 5).

I was unsuccessful in identifying nerve fibers to the volar interosseous artery and other minor vessels which I have not named.

This, however, does not imply that no nerves are given off to these vessels. Had time permitted the making of a greater number of dissections, filaments undoubtedly would have been ultimately isolated in some instances.

Fig. 5 Diagram to show the distribution of branches from the deep terminal ramus of the radial nerve (posterior interosseous) to the corresponding artery, and of the radial and ulnar nerves to the arteries on the back of the hand.

On the back of the forearm several branches were distributed from the dorsal interosseous nerve (deep ramus of radial nerve) to the dorsal interosseous artery and its branches (fig. 5).

Although the number of limbs dissected was not large, it was sufficient to show that while considerable individual variation exists in the precise situation and origin of the nerve-supply of any given vessel, yet the general vascular nervous supply follows a certain well-defined plan. The proximal vessel of the limb (subclavian artery) receives its nerve-supply directly from the sympathetic chain. The more distal arteries are supplied by sympathetic fibers which have traveled to their distribution along special nerve-trunks and not along main vessels. These twigs are distributed to the vessels from the nerve-trunks at intervals; the intervals growing shorter as the more distal portions of the limb are reached, as though a greater wealth of nerves was needed in these parts. Possibly the diminishing size of the member and consequently the greater need for constant regulation in size of vessels may be associated with this fact. Again the distribution of nerves to vessels corresponds pretty closely with the distribution of nerves to the skin and musculature of the same area.

III. DISCUSSION OF RESULTS

T. WINGATE TODD

That the nerve-supply of the bloodvessels presents considerable clinical significance has been illustrated by recently recorded cases of cervical rib (e.g., 10). The clinical appearance of the vessels in this disease has been noted in many cases by various writers. Hence it is possible to give briefly the characteristics.

Vascular symptoms commence in the fingers and spread upwards into the forearm: the radial or ulnar arteries or both may be entirely obliterated. The obliteration may proceed with considerable rapidity up the brachial artery. Occasionally the obliteration reaches the subclavian artery, as in the case of C. F. L., described by Keen (11). The rapidity of the process is illustrated by the following notes of a case in a single woman twenty-nine years of age, which came under my observation last year.

Exfoliation by dry gangrene of the tip of the right index finger occurred on July 4, 1912. By the third week in August the pulse could no longer be felt at the elbow. On September 19

the pulse ceased at the level of the insertion of the *M. coracobrachialis*. The pulse in the brachial artery became weaker until September 26, but could still be felt below the posterior fold of the axilla and the pathological change in the arterial wall remained stationary from that date.

The subclavian artery beyond the *M. scalenus anterior*, if not obliterated, appears frequently dilated. This was so in cases recorded by Keen (11) and Hamann (12).

The interference with the circulation in the large vessels is not shared by the smaller arteries in every instance. In Keen's case, (C. F. L.), the circulation in the arm generally was unaffected in spite of the fact that no pulse could be detected in any of the large vessels from the subclavian artery to the wrist (11). In one case of mine mentioned recently, pulsation could distinctly be felt in some small arteries, although absent in the larger ones (13). This curious phenomenon has been noted experimentally by Lapinski (14), while the lack of tone in the subclavian and axillary vessels referred to above has been shown by Cehanovič to occur in experimental lesions (15). The delay of the pulse so often noted in the disease was found by the latter author to be due to the lack of tone in the vessel wall. As regards the early stage of the disease, few exact observations have been made. The clearest statement is that of Osler (16). This author found that in one of his cases the radial pulse on the two sides seemed normal and equal during rest. After some exertion the pulse on the affected side (right) became very small, only just perceptible in fact; the arm becoming congested and cyanotic.¹ As the fallacy of the accepted views on delay in pulse wave and interference with circulation generally, has previously been shown (9), it simply remains for me to state the view to which Mr. Kramer and I have arrived by our present study of the anatomical facts.

The subclavian artery, being supplied directly by a sympathetic twig from the region of the *ansa subclavia*, is but rarely and secondarily affected in the disease known as 'cervical rib.' This twig is not caught in the lesion because it lies alongside the

¹ In a recent personal communication, Sir William Osler confirms this statement and assures me that the fact was noted by many observers in this case.

artery which is not locally damaged. The filaments passing to the more distal vessels, especially to those of the fingers, become affected in certain instances. For precise information regarding the anatomical facts bearing on this point, reference must be made to previous papers from this laboratory. From a study of such cases as that of Osler's, already mentioned, the lesion would seem at first to produce stimulation of the vaso-constrictor nerves, the pulse becoming temporarily small and barely perceptible. Later, paralysis of the vasoconstrictors is indicated by the dilatation and lack of tone with consequent delay in the pulse shown by Cehanovič's experimental work. This dilatation is sometimes apparent in the axillary and distal subclavian arteries in advanced cases. Following on the damage to the nerves, changes occur in the vessel wall which result in obliteration of the lumen and transformation of the artery into a fibrous cord. This action is selective. For just as some muscles escape, certain vascular areas remain unaffected and, in many cases, carry on the circulation in the limb. The reason for this selective action is not yet apparent. As already indicated, there is a tendency for large vessels to be affected and for the smaller ones to escape. Doubtless the cause of this will be found in the distribution of the precise fibers to the several vessels. But at present no definite statement can be made. There is certainly a kind of plexus formation throughout the length of the limb, produced by the interchange of vascular filaments from one large nerve-trunk to another. Exceedingly significant, when one considers the origin and distribution of vascular nerves, is the observation of Weir Mitchell (19) that 'trophic' changes are most prone to follow wounds of the nerves to hand or foot (i.e., lowest cord of brachial plexus in which the majority of the vascular nerves exist) and more rarely occur when the injury has involved nerve branches which supply the upper portion of a limb (p. 38). A striking instance is cited in Case 29 of Weir Mitchell's series (p. 167).

The veins are also affected in the disease, but they lie outside the scope of the present paper, and will be considered on some future occasion.

The practical bearing of the anatomical research at present being prosecuted on the subject of nerve-supply to bloodvessels has been convincingly shown by my erstwhile colleague, Mr. E. D. Telford, in a recent paper in which are to be found details of two cases of neuro-vascular derangement consequent on the presence of cervical ribs, which were subjected to operation with the express purpose of arresting a progressive mechanical lesion of the vascular nerves (20).

Not only was the condition relieved by operation but the symptoms produced by the lesion completely disappeared. In Case II, from which we took a short length of the radial artery, the pulse has not reappeared in the main vessels, but in Case I the radial pulse first returned four months after the operation. Only after our experimental work is finished can we state what happened to the artery in order that the pulse might return. The vessel may have been canalized or a new artery may have grown in the substance of the obliterated vessel, as occurs in the uterus after child-birth.

It is certainly a suggestive fact that the pulse should return four months after operation, when one associates this with the observations of Head and Rivers, who state that the vascular condition of the limb commenced to return to the normal, in their experiment, in 107 days and was quite normal in 190 days after section and primary suture of the superficial ramus of the radial and of the musculo-cutaneous nerves at the level of the fossa cubitalis (21).

In conclusion, it is necessary to point out that a study of the neuro-vascular arrangements in the arm has led me entirely to alter my views from those which I held in 1911, on the causation of the vascular phenomena in 'cervical' rib cases.

For an account of the circumstances leading to this change of view, Dr. Wood Jones' paper before the Royal Society of Medicine, may be consulted (17). My present views on the subject lead me to submit an entirely different description of the method of causation of the pulse characteristics from that given some years ago by Babcock (18).

IV. SUMMARY

1. The subclavian and axillary arteries differ from the other arteries of the arm in receiving a nerve-supply direct from the sympathetic chain.

2. All other arteries in the upper limb obtain their nerve-supply from sympathetic filaments which have traveled along the spinal nerves and which are distributed to the various blood-vessels at irregular intervals.

3. The distal and peripheral vessels, more particularly those of the hand, receive nerve filaments at more frequent intervals than do the proximal channels.

4. The distribution of nerves to vessels corresponds roughly with the distribution of nerves to muscles and skin.

5. The fact that the subclavian trunk derives its nerve-supply direct from the sympathetic chain accounts for its escape from involvement in the lesion associated with the disease known as 'cervical rib.'

6. Paragraph 4 explains the early involvement of the arteries of the hand in the type of cervical rib lesion in which the vessels are affected.

7. The process of the bloodvessel affection appears to be (a) stimulation of vasoconstrictor fibers, (b) paralysis of vasoconstrictors (with undisturbed action of vasodilators ?) (c) pathological changes in the vessel wall consequent on the lesion of the nerves.

8. For the site and cause of the nerve lesion previous papers from this laboratory must be consulted.

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