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NEW FACTS ABOUT THE PATHOGENESIS OF DUPUYTREN'S CONTRACTURE

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There are still a number of aspects of the aetiology and pathogenesis of Dupuytren's contracture of fingers that require clarification. Proceeding from clinical research extending from Dupuytren's time (1832) to this day medical scientists have advanced many ideas concerning the causes of this condition. In the present report, rather than wishing to refute this or that theory, we intend to draw the reader's attention to some of the well established facts arrived at by many authors as a result of their observations of patients with Dupuytren's contracture regardless of what actual causes of the disease they had in mind. Clinical research shows that Dupuytren's contracture of fingers is encountered in 10 to 15 times as many men as women, and that digits 4 and 5 of the hand are the most likely to be involved. According to literary data, patients aged 30 to 60 years are by far the largest group. The right hand is more likely to be involved, though bilateral involvement clearly predominates. The above facts arise from clinical research and are hardly ever questioned, though in our study of the relevant literature and that even in the monograph "La malaide de Dupuytren" compiled by 20 famous specialists of Europe, America and Australia in Paris in 1972 (second edition), we failed to find an answer to questions raised by those clinically established facts.

Why then should the fingers of the ulnar side be affected the most frequently by Dupuytren's contracture regardless of the patient's sex and age and side of the body? An explanation of this might, in our opinion, give us a clue to the detection and understanding of the aetiological moments and pathogenesis of Dupuytren's contracture of fingers. As we see it, a logical answer to this question can only be derived from a thorough topographical study of the palmar aponeurosis — the anatomical substrate of Dupuytren's contracture. It should be pointed out that similar studies of the palmar aponeurosis are often crowned with success or can give answers to these and other disputed questions. Thus, for instance, the Krogius constitutional theory of the cause of this pathological condition (1920) held good for fifty years.

According to the Krogius theory, the development of Dupuytren's contracture is due to the atavistic invasion of the palmar aponeurosis by muscular elements of the m. palmaris brevis. Yet Dylevski (1970), studying serial sections of the hand of human embryos and foetuses under an electron microscope, never found any such invasion, which led him to the complete rejection of the Krogius theory.

According to A. P. Nadein and M. G. Krasilnikova (1953) and Stilwell (1957), the palmar aponeurosis is innervated from branches of the n. medianus, n. ulnaris, n. lateralis et n. cutaneus antebrachii medialis and n. musculocutaneus. Our research centered on studies of the histotopographic deployment of the terminal branches of those nerves in the palmar aponeurosis with the use of the neurohistological methods of Bilshovski-Gross and Habonero. The research material consisted of 70 hands of human embryos and foetuses aged from two months of development in utero up to birth, and 14 adult hands. With regard to the small size of the hand and the difficulties involved in the dissection of embryonic and foetal palmar aponeurosis by

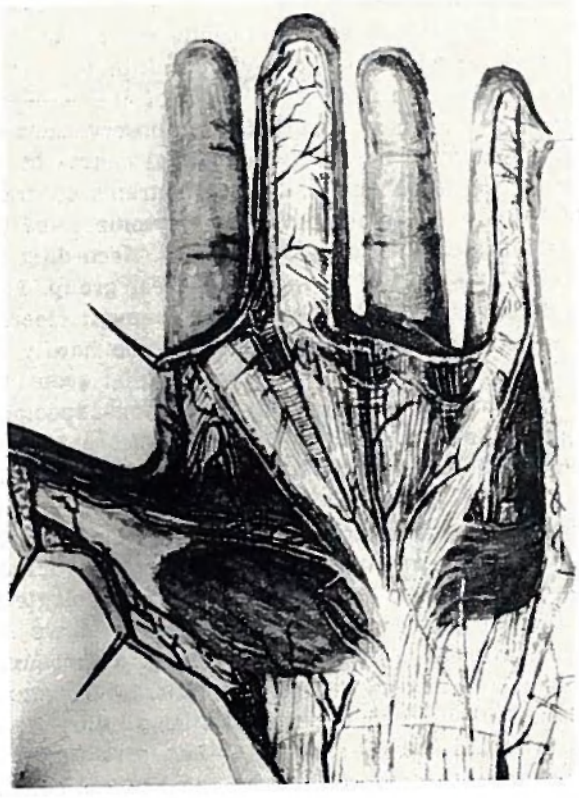

Fig. 1 Palmar aponeurosis — the norm (according to Kovanov and Travina, 1965)

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means of the cryostat, cross sections of the whole hand were made. Work with this material was conducted so as to preserve the same topographical and anatomical relations on the palmar surface of the hand. To study the palmar aponeurosis of adults (Fig. 1) and of foetus 8 to 10 lunar months old we divided the structure into three parts: the proximal part (between the thenar and hypothenar), the middle and the distal portions of palmar aponeurosis. The distal portion of foetuses was then divided into the ulnar and radial parts, and — in adults — into ligaments to digits 2, 3, 4 and 5.

What did we find?

1. We found no difference whatsoever in the anatomical structure of the male or female palmar aponeurosis regardless of the side of the body or of the presence or absence of the m. palmaris longus.

2. We failed to prove any difference in the sensory innervation of the palmar aponeurosis between men and women, or between the right and left hands.

At the same time, we found out quite accurately that the central portion of the palmar aponeurosis has more thinly distributed receptors as has the connective tissue of the palmar aponeurosis of digit 3. Not only that, the most frequently demonstrated receptors in the palmar aponeurosis of the Vater-Pacini corpuscle type as much as in its deep layers reach a length of 1 to 1.5 millimetres, while in the other parts of the structure, particularly so in its superficial layers as much as 4 mm (Fig. 2). Another finding is that beginning with 4.5 to 5 months of embryonic development the ulnar margin in the distal part of the palmar aponeurosis (i. e., ligaments of digits 4 and 5) is more abundantly supplied with encapsulated receptors of the type of Vater-Pacini corpuscles. This characteristic pattern of deployment of receptors (their histotopography) is a life-long feature. According to our data, the ulnar margin of the palmar aponeurosis has a maximum supply of sensitive nerve endings, especially Vater-Pacini corpuscles. As already mentioned with reference to literary reports, Dupuytren's contracture most frequently affects the ring and little fingers, i. e., the ulnar marging of the palmar aponeurosis, independently of the patient's sex.

Next, beginning with the 5th month of embryonic development, we studied the interrelationship between the platelet-like Vater-Pacini corpuscles, the most widely represented in the palmar aponeurosis, and blood vessels (Fig. 3). Unfortunately, we failed to obtain a complete idea of the blood supply of the Vater-Pacini corpuscles from that material. This is probably due to the fact that the tissue of palmar aponeurosis is cut in serial surface sections while the Vater-Pacini corpuscles are also cut superficially into parts.

With regard to the fact that a study of the relationships between blood vessels and the receptors of the human palmar aponeurosis could be of great importance to account for some of the mechanisms of the pathogenesis of Dupuytren's contracture, we decided to study the palmar aponeurosis in great detail with the method of silver injection according to Ranvier. As material, we used ten hands of practically healthy persons who died in accidents, which we received within 24 hours of the fatal injury.

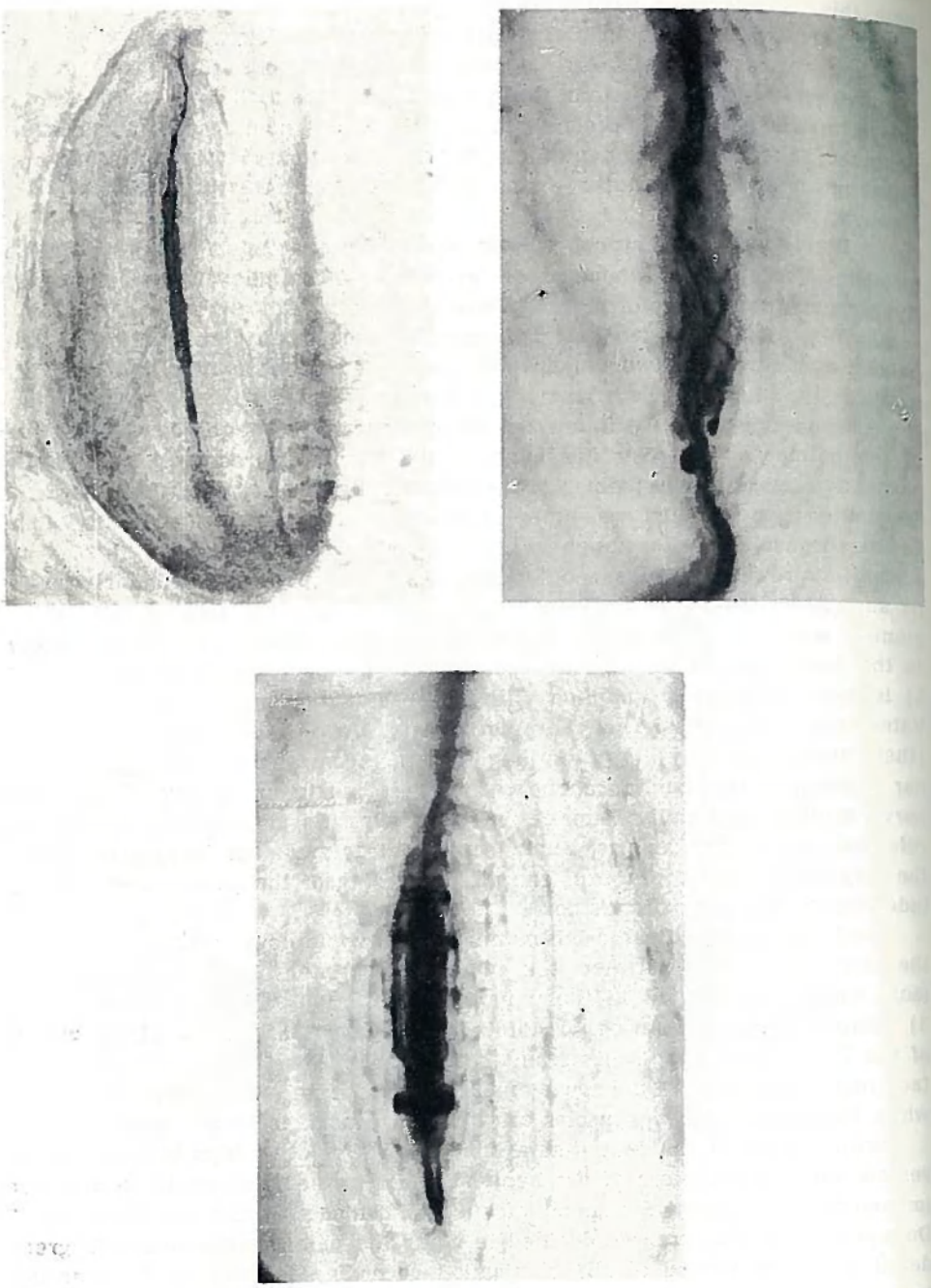

Fig. 2 Vater-Pacini corpuscles in the middle portion of palmar aponeurosis (a), near the ulnar margin of distal part (b, c)

palmar aponeurosis (a), near (b, c)

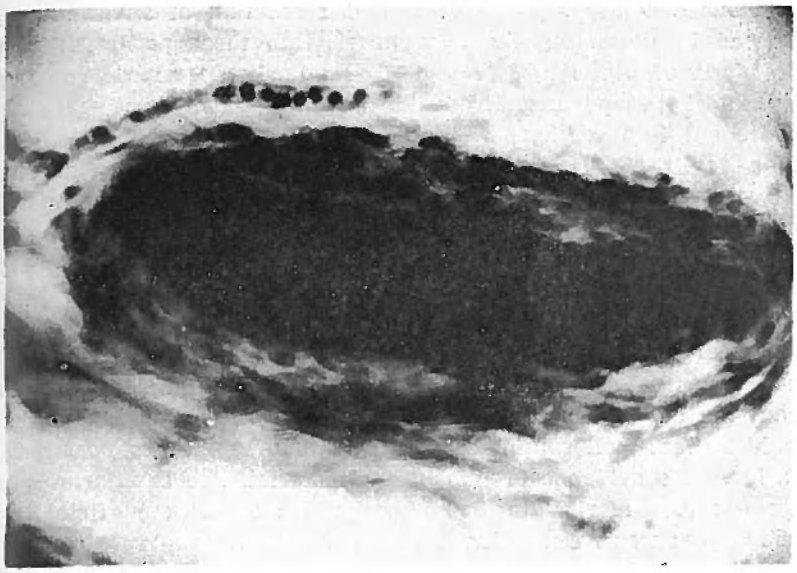

Fig. 3 Incipient Vater-Pacini corpuscle in intricate interrelationship with a blood vessel (with erythrocytes seen inside). Stained after Benda Spilmmer, × 40. Here and next = microphotographs

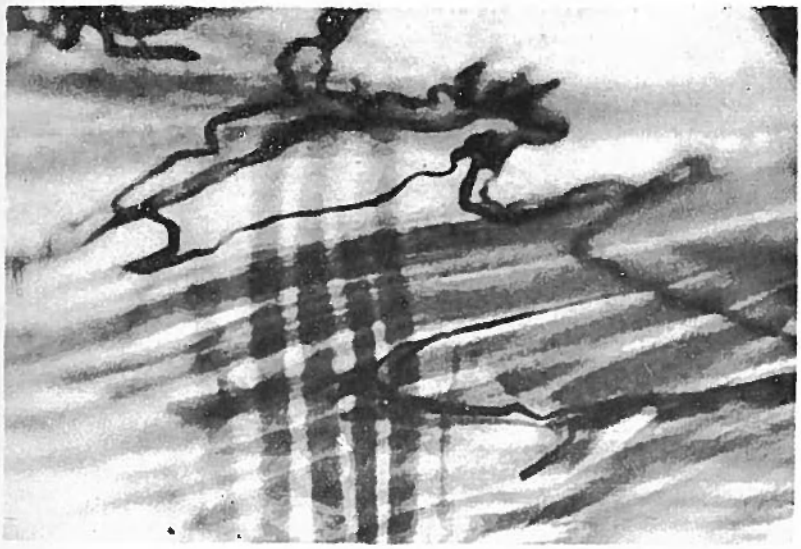

Fig. 4 Blood vessels of palmar aponeurosis (norm). × 8 — here and next. Fig. 4—10 — silver nitrate injection acc. to Ranvier

Using the ulnar and radial arteries, the hands were washed with distilled water and subsequently injected with 1—2% solution of silver nitrate. This was followed by dissecting the aponeurosis into three parts with exposure of the tendons of digits 2, 3, 4 and 5 as already described. The proximal, medial, parts of the aponeurosis and the tendons of the distal portion (separately) were cut into sections 350 microns thick and left in distilled water exposed to daylight for one up to 2 days. After staining with carmine, the sections were embedded in Canada balsam with the use of routine methods.

The palmar aponeurosis is one of the bradytrophic tissues supplied, according to Damcha Bayanbeleg (1978), by penetrating vessels arising from the superficial palmar arch of arteries and common digital arteries. In the author's view, the proximal portion of the palmar aponeurosis — as distinct from the distal part — has the most favourable conditions for vascularization because of the proximity of the radial and ulnar arteries. These data seemed to warrant the conclusion that even the Vater-Pacini corpuscles in the distal part would be less well supplied with blood than in the proximal part. However, we found no evidence of this in our material. The capillaries supplying the large (up to 4 mm) Vater-Pacini corpuscles of the superficial layers of the palmar aponeurosis were clearly found to constitute a more densely ramified network that those supplying the corpuscles of its deep layers. Surface sections of the palmar aponeurosis along with parts poorly supplied with blood vessels (Fig. 4) show areas of abundant capillaries (local microvascular networks -- Fig. 5) interspersed with avascular zones. The vessels mostly reach the corpuscle from one pole, as a rule, with a nerve fibre (axial

Fig. 5 Local microvascular bed in palmar aponeurosis (norm)

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Fig. 6 Middle portion of adult human palmar aponeurosis. Capillary network on the surface of a Vater-Pacini corpuscle (ramifications of arterioles)

Fig. 7 Group of Vater-Pacini corpuscles (3) and a network of blood vessels on the surface and between corpuscles in deep layers of proximal palmar aponeurosis of an adult

cylinder) to form a capillary network inside the receptor and on its surface (Fig. 6, 7). Occasionally, the blood vessels (arterioles) approach the corpuscle from different poles or from the side to ramify on its surface in the form of dense capillary network enveloping the corpuscle in a net-like fashion (Fig. 8, 9). As a rare occurrence, there may be groups of 2 to 3 corpuscles supplied with blood from one source with the branches of a single artery supplying the tissue, bundles of nerve fibres and Vater-Pacini corpuscles of palmar aponeurosis (Fig. 10).

Fig. 8 Blood vessels on the surface of a large (4 mm) corpuscle of the surface layer of aponeurotic tendon of digit 4

DISCUSSION AND CONCLUSIONS

Our material concerning the receptor innervation of the human palmar aponeurosis beginning with prenatal ontogenesis stands to prove the complex structure and abundance of the nervous system located in it. The characteristic pattern of distribution and the uneven size of the receptors (Vater-Pacini corpuscles) most frequently found there apparently keep the CNS supplied with a wide range of different signals from the whole palmar aponeurosis and, in particular, from those of its parts which are exposed to the strain and pres-

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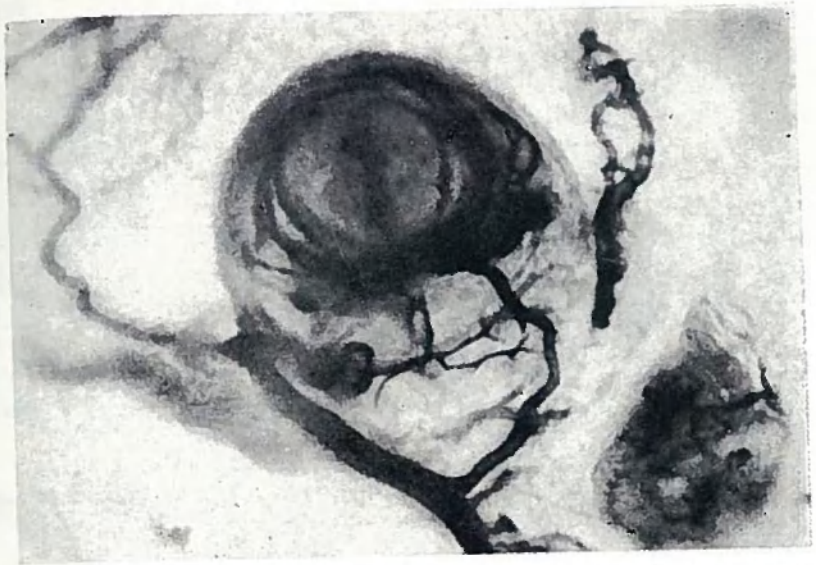

Fig. 9 Digit 3 tendon of palmar aponeurosis. Blood vessels (ramification reaching the corpuscle) on the pole of a Vater-Pacini corpuscle

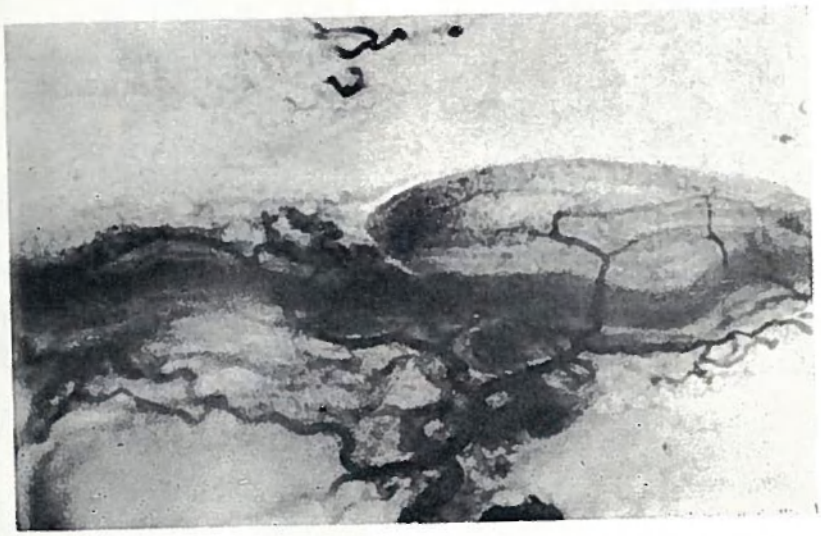

Fig. 10 Digit 5 tendon of palmar aponeurosis. Two Vater-Pacini corpuscles running parallel to a nerve fibre (above and below) in intricate interrelationship with the branches of a single blood vessel

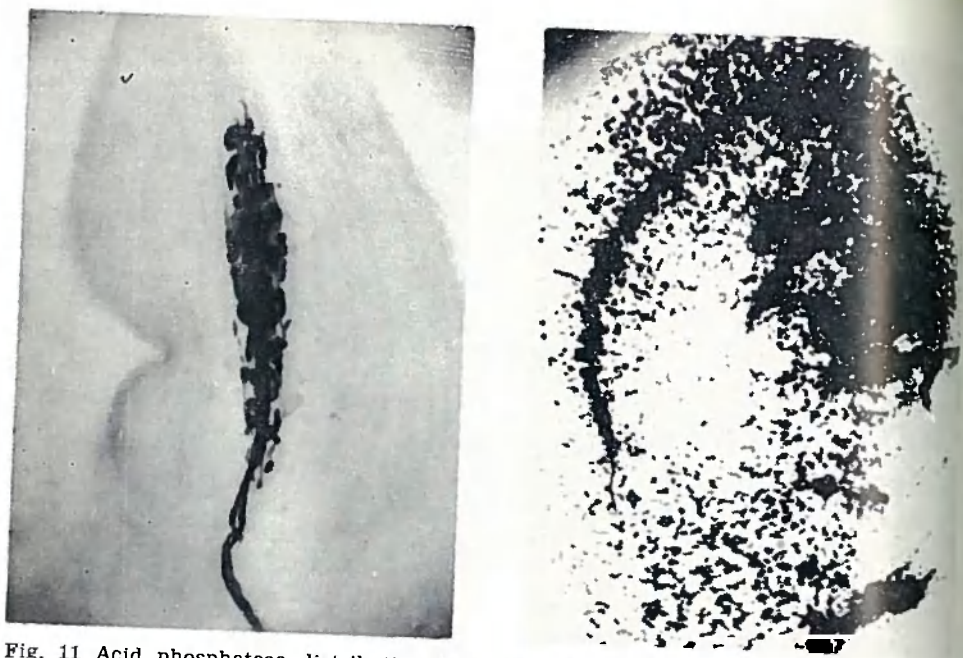

Fig. 11 Acid phosphatase distribution in a Vater-Pacini corpuscle of palmar aponeurosis (norm.)

Fig. 12 Incipient Dupuytren's contracture. Acid phosphatase distribution in a Vater-Pacini corpuscle

Fig. 13 Dupuytren's contracture — stage 1. Deformed Vater-Pacini corpuscle and degenerated nerve fibres running parallel

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sure of physical manual work. As already mentioned, beginning with the 4.5 to 5th months of embryonic development the ulnar side in the distal portion of palmar aponeurosis (i. e., tendons of digits 4 and 5) is more amply supplied with receptors of the Vater-Pacini corpuscle type. This characteristic pattern of receptor distribution (histotopography) is a lifetime feature. Clinical experience alone shows that regardless of the patient's sex and age the 4th and 5th digits of the hand, i. e., the ulnar margin of the palmar aponeurosis which, in accordance with our findings, is the most abundantly supplied with sensitive nerve endings is also the most likely to be affected by Dupuytren's contracture. In addition to that, we were able to note intricate interrelationships between the blood vessels and the Vater-Pacini corpuscles of the palmar aponeurosis as well as the existence of a dense capillary network on the surface of those receptors independently of the actual part of the aponeurosis.

Referring to his anatomical study of the palmar aponeurosis blood supply system, Bayanbeleg describes the distal portion of the aponeurosis as having less favourable conditions of blood supply, which, in his view, accounts for the intensive process of sclerotization in this particular part of the structure. However, the question arises of why the sclerotic processes in the distal portion of the palmar aponeurosis should develop the most frequently in the tendons of digits 4 and 5, i. e., on the ulnar side of the aponeurosis, rather than in the tendons of all the fingers. On the other hand, advocates of the traumatic theory of the development of Dupuytren's contracture point out that in hard manual work there is impaired blood circulation as a primary feature due to the permanent oppression of the palmar aponeurosis between the tool and the bones of the hand. Like others, Frydland (1954) believes that Dupuytren's contracture may arise from locally impaired blood supply due to a variety of causes: chronic trauma, prolonged strain, e. g., in pianists, violinists, etc.

In connection with the fact that Dupuytren's contracture is most likely to affect digits 4 and 5 of the hand, i. e., the ulnar side of the aponeurosis with its ample supply of nerve endings, mostly Vater-Pacini corpuscles, we attribute the pathogenetic causes of Dupuytren's contracture to a primary impairment of microcirculation in the proprioreceptors of the palmar aponeurosis which again may be due to different causes. Quite possibly, microcirculatory changes in the aponeurosis may have a role to play there. To give substance to this idea we studied the histophysiology of the Vater-Pacini corpuscles using the histochemical methods of Gomori, Kelli-Friedenwald in Gomori's modification for assays of alkaline and acid phosphatase, cholinesterase. As material for this study, we used the palmar aponeurosis of practically healthy persons and degenerated aponeurosis obtained from surgical operations with the removal of "healthy" part in 12 patients with Dupuytren's contracture of different stages of development.

What were the findings?

A prominent increase in acid phosphatase compared with the norm (Fig. 11, 12) and a decrease in alkaline phosphatase activities in the Vater-Pacini

corpuscles were noted already in the initial stages of Dupuytren's contracture while cholinesterase levels remained unaltered. In our view, these phosphatase activity changes are due to a primary marked disruption of metabolic processes in the Vater-Pacini corpuscles. Similar changes in the nervous system were found in the skin of lower extremities in cases of obliterating endangiitis (Golikova, 1962). Moreover, already in the initial stages, a degenerated palmar aponeurosis shows the presence of deformed Vater-Pacini corpuscles and degenerative dystrophic changes in the nerve endings (Fig. 13). In severe cases of Dupuytren's contracture, no Vater-Pacini corpuscles are present any more in the dense tissue of a degenerated aponeurosis.

The blood capillaries, so abundantly present in the proprioreceptor structures, have the same role to perform as those in other organs and tissues, namely to supply oxygen and nutrients in large quantities as required by the function concerned. Local hypoxia invariably drives tissue metabolism to the anaerobic side with an accumulation of underoxygenized metabolities and acid mucopolysaccharides. Oxygen supply is known to be indirectly proportional to the tissue content of mycopolysaccharides.

As shown by I. I. Rusetski (1950), there are six basic localizations of pathological processes related to dystrophy, all of them due to disorder in any of the structures of the autonomous nervous system (beginning with nerve ending receptors). Another source of dystrophy can be traced to the sympathetic terminal and spinal ganglia closely connected with the lateral horns of spinal cord, the lateral horns themselves and the autonomous structures of the medulla oblongata. The diencephalic region, too, has a role to play there. Clearly then, depending on the degree of primary autonomous nervous system involvement and on the intensity of stimulation, vegetative dystrophy of various degree is likely to develop, a process which we were able to see in our own patients, too.

Dupuytren's contracture of fingers should then be seen as a polyaetiological condition, in the genesis of which both exogenous and endogenous factors act in interdependence.

SUMMARY

A histotopographical study is presented of the innervation of the palmar aponeurosis in human embryos and foetuses of both sexes and in adults. Beginning with the 4.5 to 5th months of embryonic development and later on in adults, too, the ulnar margin of the distal part of palmar aponeurosis (i. e., tendons of digits 4 and 5 most likely to be affected by Dupuytren's contracture) is the most abundantly equipped with encapsulated receptors of the type of Vater-Pacini corpuscles. With reference to a study of the microcirculation of palmar aponeurosis proprioreceptors in the norm and to the histophysiology of Vater-Pacini corpuscles in the norm and in Dupuytren's contracture the author presents the view that primary impairment of microcir-

culation in the proprioreceptors of palmar aponeurosis due to a variety of causes is part of the basic pathogenesis of the condition.

Key words: contracture, Dupuytren, pathogenesis

RESUME

Nouvelles connaissances en pathogenese de retraction Dupuytren

Mikoussef, I. E.

Effectuée l'étude histotopographique de l'appareil nerveux de l'aponevrose palmaire chez les embryons, les foetus humains des deux sexes et chez les adultes. On a constaté qu'à partir de 4,5 à 5 mois du developpement embryonnaire (aussi chez les adultes), le bord cubital de la partie distale de l'aponévrose palmaire (c'est-à-dire des tendons de 4eme et 5eme doigts, le plus souvent atteints de la rétraction Dupuytren) est au maximum pourvu en récepteurs incapsules, corpuscules de Vater Pacini en principe. S'appuyant aux études de la microcirculation des propriocepteurs de l'aponévrose palmaire chez les sujets normaux et aux études de l'histophysiologie des corpuscules Pacini chez les sujets normaux et chez les sujets atteints de rétraction Dupuytren, les auteurs presentent l'hypothese que les troubles primaires de microcirculation aux propriocepteurs de l'aponevrose palmaire, dus aux diverses origines, constituent l'élément de la notion de pathogenese de cette maladie.

ZUSAMMENFASSUNG

Neue Erkenntnisse zur Pathogenese der Dupuytren'schen Kontraktur

Mikusev, I. E.

Es wurde das histotopographische Studium der Nervensystems der Handflächenaponeurosis bei Embryos, Früchten von Menschen beiden Geschlechts sowie bei Erwachsenen durchgefuhrt. Es wurde festgestellt, dass bereits seit dem 4,5. bis 5. Monat der embryonalen Entwicklung ebenso wie bei Erwachsenen der Ellenrand im distalen Teil der Handflächenaponeurosis (d. h. der Sehne des 4. und 5. Fingers, die am häufigsten von einer Dupuytren'schen Kontraktur betroffen wird) am reichhaltigsten von eingekapselten Rezeptoren versorgt wird, im Grunde von Körperchen Vater Pacini. Auf Grund der Studie der Mikrozirkulation der Propriorezeptoren der Handflächenaponeurosis bei der Norm und der hystophysiologischen Körperchen Vater Pacini bei der Norm und bei einer Dupuytren'schen Kontraktur wurde die Erwägung in Betracht gezogen, dass ein Bestandteil der Grundlage der Pathogenese dieser Erkrankung eine primäre Störung der Mikrozirkulation an den Propriorezeptoren der Handflächenaponeurosis sei, die aus verschiedenen Gründen entsteht.

RESUMEN

Una contribución al conocimiento sobre la enfermedad de Dupuytren

Mikusev, I. E.

Se presenta un estudio histotopográfico de la inervación de la aponeurosis palmar en los embriones y fetos de ambos sexos y también en los adultos. Comenzando con 4,5—5. mes desde el desarrollo embriónico y más tarde también en los adultos, fué observado que el margen ulnar de la parte distal de la aponeurosis (es decir,

los tendones del dedo 4 y 5 los que están principalmente afectados por la enfermedad de Dupuytren) está abundantemente proveído por los receptores encapsulados, en primer lugar, por los corpúsculos de Vater-Pacini. A base del estudio de la microcirculación de la aponeurosis palmar de los propioreceptores en la norma y de la histofisiología de los corpúsculos de Vater-Pacini en la norma, el autor es de opinión que el perjuicio primario de la microcirculacion en los propioreceptores de la aponeurosis palmar, debida a diferentes causas, toma parte en la patogenesis de esta enfermedad.

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