

MORPHOGENESIS OF THE LAMELLAR RECEPTORS OF HUMAN STRIATED MUSCLE

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UDC 611.73-018.86

The structure of the lamellar receptors in the muscles of the trunk and limbs of embryos, fetuses, and children up to the age of 5 years was studied by impregnation by the Gros-Schultze method. The formation of lamellar corpuscles begins at 3.5-4.5 months of embryogenesis. By the end of the antinatal period their anlagen are mainly formed, and many Vater-Pacini bodies attain a high level of differentiation. The highest concentration of lamellar corpuscles is found in the muscles of the upper limbs.

Investigations have shown that lamellar receptors occupy an important position among the various types of sensory endings in the human body. They are evidently not merely transmitters of exteroceptive and interoceptive stimuli, but also mediators of proprioceptive sensation. They are found in the tissues of organs of the locomotor system, including skeletal muscle [2, 3, 6, 8-10].

EXPERIMENTAL METHOD

Receptor endings were studied in the muscles of 50 embryos, fetuses, and children up to the age of 5 years. In each case 10 different muscles were taken for histological study, including the sterno-cleido-mastoid, pectoralis major, intercostal muscles, the rectus abdominis, biceps brachii, flexor digitorum superficialis, the abductor pollicis brevis, rectus femoris, gastrocnemius, and flexor digitorum longus (lower limb) muscles. The same parts of the muscles at the junction between muscle tissue and the tendon, together with a strip of tendon, were taken for investigation.

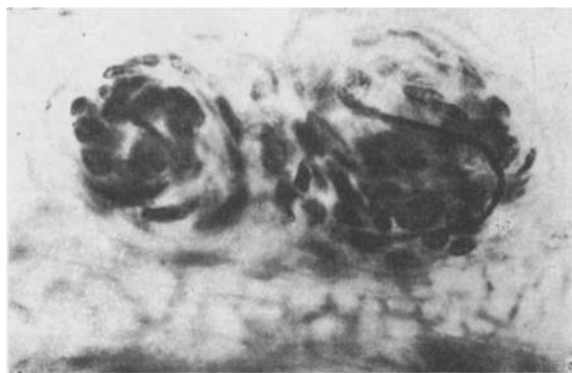


Fig. 1. Formation of lamellar receptors in flexor digitorum superficialis muscle of 6-month fetus. Photomicrograph, Gros-Schultze, 400 \times .

Sections in the embryos were taken through the whole limb. The material was fixed in 12% neutral formalin solution. Frozen sections, 25-30 μ in thickness, were stained with silver nitrate by the Gros-Schultze method. The microscopic structure of more than 4000 sensory endings in the skeletal muscles of fetuses and children up to 5 years of age, including 385 lamellar receptors, was studied in detail. Biometric measurements were made with an ocular micrometer.

EXPERIMENTAL RESULTS

The formation of lamellar receptors in human skeletal muscles begins at the end of the first half of intrauterine development, and soonest in the muscles of the upper limbs. In the muscles of the thenar

Department of Normal Anatomy, Izhevsk Medical Institute. (Presented by Academician of the Academy of Medical Sciences of the USSR A. P. Avtsyn.) Translated from *Byulleten' Éksperimental'noi Biologii i Meditsiny*, Vol. 71, No. 2, pp. 102-104, February, 1971. Original article submitted June 23, 1970.

TABLE 1. Dimensions of Vater-Pacini Corpuscles in Skeletal Muscles of Children under 2 Years of Age

Muscle	Size of corpuscle (in μ)	
	minimum	maximum
Sterno-cleido-mastoid	413.6 \times 48.4	343.2
Pectoralis major	506.6 \times 136.4	732 \times 132
Biceps brachii	277.5 \times 122.1	876.2 \times 244.2
Flexor digitorum superficialis	418 \times 149.6	721.5 \times 277.5
Abductor pollicis brevis	264 \times 127.6	616 \times 264
Rectus femoris	—	484 \times 176
Flexor digitorum longus	484 \times 88	532.4 \times 176

TABLE 2. Percentage of Lamellar Receptors Relative to Total Number of Sensory Endings in Skeletal Muscles of Fetuses and Children under 2 Years of Age

Muscle	Percent of lamellar corpuscles
Abductor pollicis brevis	13.47
Biceps brachii	11.51
Gastrocnemius	7.2
Pectoralis major	7.11
Flexor digitorum superficialis	4.66
Rectus abdominis	4.35
Flexor digitorum longus	3.12
Sterno-cleido-mastoid	2.88
Rectus femoris	2.5



Fig. 2. Vater-Pacini corpuscle in biceps brachii muscle of infant aged 5 months. Photomicrograph, Gros-Schultze, 80 \times .

eminence, single receptors were found in 3.5-month fetuses, and in other cases somewhat later (4-4.5 months of embryogenesis). In this period they are small ($44 \times 39\mu$) and very primitive in structure. In the center of a developing receptor of this type are the axon and the circular and oval glial nuclei, while at the periphery there are one or two rows of elongated cells connected together by protoplasmic processes (Fig. 1).

By the age of 5.5-6 months of embryogenesis the number of lamellar receptors is appreciably higher, and they include Vater-Pacini corpuscles and lamellar receptors of intermediate type. The Vater-Pacini corpuscles are enlarged ($382 \times 154\mu$), and their capsule consists of 6-12 layers of connective-tissue lamellae with oval and elongated nuclei, and the inner bulb occupies half or two-thirds of the diameter of the receptor. By the end of the embryonic period, the Vater-Pacini corpuscles have attained a high level of differentiation. The capsule is thickened, the relative size of the inner bulb is reduced, and it now

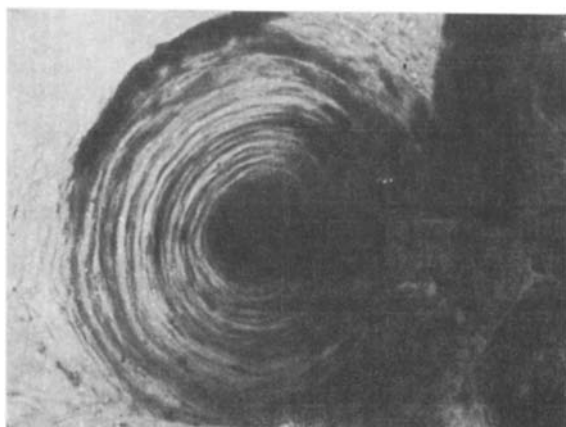


Fig. 3. Vater-Pacini corpuscle (transverse section) in rectus abdominis muscle of child aged 1 year 9 months. Photomicrograph, Gros-Schultze, 280 \times .

occupies between one-third and one-quarter of the diameter of the receptor; the axon is mostly single, and only occasionally are corpuscles with two or three terminal fibers found.

In the postnatal period, during the first year of life, the number of mature forms of Vater-Pacini corpuscles increases. At the same time, the number of intermediate lamellar receptors is reduced, and in the muscles of children aged 1 year they are much less frequently seen than in fetal muscles. They are evidently transitional, and during growth of the organism they differentiate into typical Vater-Pacini corpuscles (Figs. 2 and 3; Table 1).

In children aged 3 years the Vater-Pacini corpuscles are externally almost indistinguishable from those in adults. Their outer capsule contains 22 connective tissue lamellae less than 1μ in thickness, be-

tween which small blood vessels can sometimes be seen. Besides the usual simple Vater-Pacini corpuscles, others of more complex structure, with two or three inner bulbs, may be found.

The lamellar receptors are found singly and in groups (of up to 3) in the connective tissue between bundles of muscle fibers, most frequently at the junction between the muscle tissue and the tendon, along the tendon bands, and side by side with nerves and blood vessels. Muscles in different situations and with different functions differ in their supply of lamellar receptors, and they are most numerous in the muscles of the upper limbs (Table 2).

It is interesting to note that with increasing age the number of Vater-Pacini corpuscles per unit area decreases. This is evidently because the process of laying down the lamellar receptors is largely complete by the end of embryogenesis [1, 4, 5, 7].

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