FEATURES AND LEVEL OF STRUCTURAL ORGANIZATION OF THE FIRST REFLEXES IN THE HUMAN FETUS

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K. V. Shuleikina and N. G. Gladkovich

Laboratory of Human Embryology, Institute of Obstetrics and Gynecology,
Ministry of Health of USSR, Moscow
Presented by Academician P. K. Anokhin
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The first reflex observed in the human fetus and the fetuses of a number of animals is one of contralateral flexion of the neck in response to tactile stimulation of the upper lip and ala of the nose, both in the zone supplied by the trigeminal nerve. This reflex is first seen in human embryos of 7.5 weeks. As the fetus develops, flexion of the neck is replaced by extension with additional contraction of trunk and limb muscles [14-21]. This reflex is known as the "avoidance reaction". Some authors [17, 18] assess it as the phylogenetically oldest form of animal behavior, being a reflex of defense or withdrawal from danger. From about 9.5 weeks the zone supplied by the trigeminal nerve becomes the reflexogenic field for the future sucking reflex, which is an element of another vitally important functional system, the alimentary system [4, 5, 15-27].

The first reflex reactions, which develop in connection with stimulation of sensory endings of the trigeminal nerve, are thus representative of the embryonic evolution of two of the oldest and most important aspects of the vital activity of animals, namely defense and nutrition. An understanding of the structural organization in the nervous system of these early trigeminal reactions is therefore of considerable theoretical importance.

Lateral flexion of the neck is one of the fetal reactions which have been the subject of considerable research. Systematic investigations, carried out by a number of authors, make it possible to obtain a fairly complete picture of the structural development of this reflex. The development of the spinal nucleus of the accessory nerve, which is the main motor center for the flexors of the neck [18, 21], has been described [26]. The morphogenesis of the descending root of the trigeminal nerve and its endings, which constitute the afferent part of the reflex arc, has been studied in detail [18-20]. The system of intermediate neurones and the earliest mechanisms for the closure of spinal reflex arcs has also been described [11, 12, 20, 21, 33, 34, 35].

Yet there is a considerable volume of evidence that axons of cerebrospinal pathways can be demonstrated in the white substance of the spinal cord in quite early stages of embryogenesis [11 12, 14, 18, 21, 29, 34]. This would indicate that cerebral structures must presumably play some part in the integration of the early functions of the fetus. At the moment, however, this question is still undecided.

The authors have shown in an investigation dealing specifically with this problem that, in the case of the grasping reflex, a bundle of fibers from the anterior column grows into the motor center for the digital flexors (C_8) at about the time when flexion of the fingers is first observed. Analysis of the origin of these fibers suggests that they are axons of descending tracts originating in the brain stem [6, 8, 9, 10].

An attempt was now made to determine the features and level of central integration of a still earlier reflex in the human fetus, namely lateral flexion of the neck. The development and course of fibers leaving the anterior column in the region of the motor center for the flexors of the neck (C_{1-3}) were therefore investigated and the results were compared with what is known of the development of corresponding structures at the level of the eighth cervical segment, studied earlier, where the center for the digital flexors is situated.

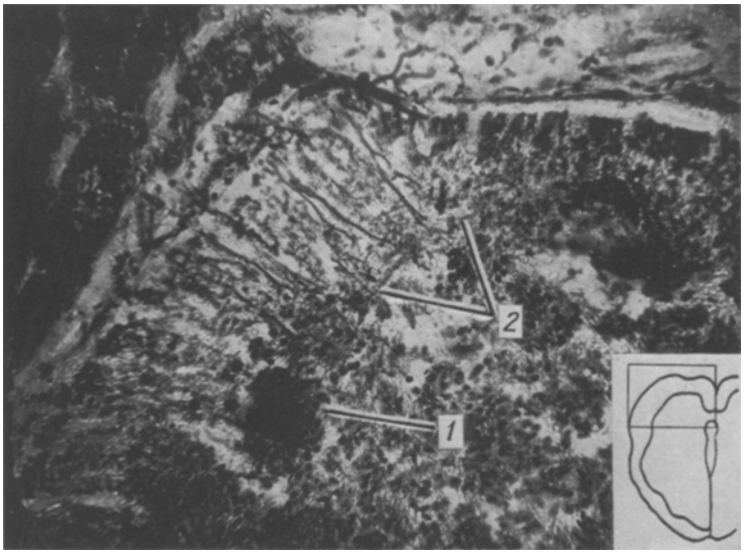

Fig. 1. Appearance of presynaptic collaterals in region of spinal nucleus of accessory nerve (3rd cervical segment). $7^{1}/_{2}$-weeks fetus; 1) spinal nucleus of accessory nerve; 2) group of presynaptic collaterals. Peters impregnation method. ×200.

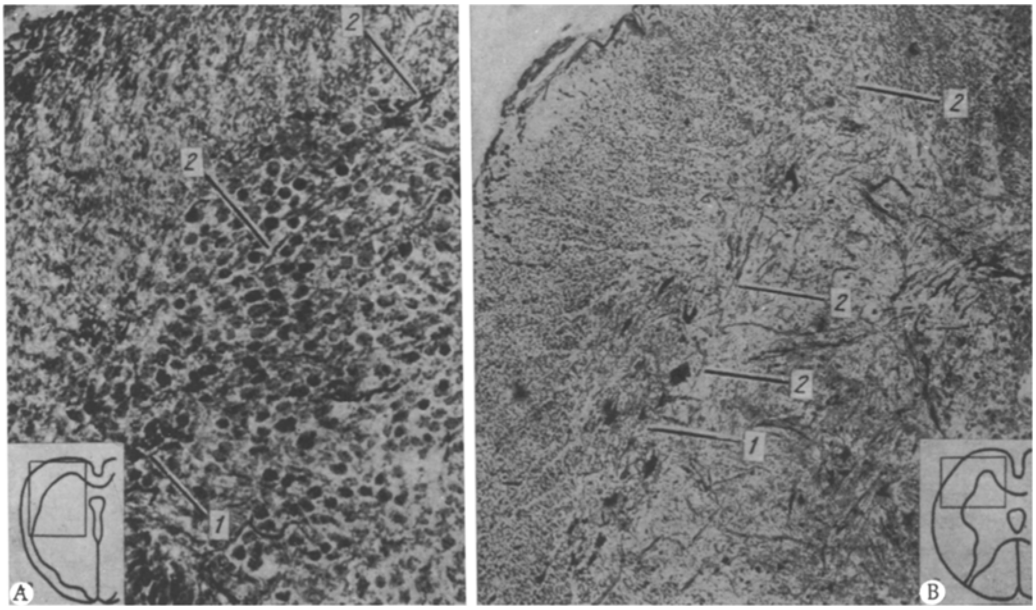

Fig. 2. Presynaptic collaterals of anterior column at level of spinal nucleus of accessory nerve (3rd cervical segment). A) $8^{1}/_{2}$-week fetus. B) 19-week fetus; 1) spinal nucleus of accessory nerve; 2) presynaptic collaterals, Peters impregnation method. ×300 (A) and ×140 (B).

METHOD

Preparations from the spinal cords of ten human fetuses of from 7.5 to 21 weeks were examined. The age of each fetus was determined from Schultz's table [31]. Peters' protein silver method was employed and the preparations were counterstained with cresyl violet [27, 28]. The results described here are those obtained with fetuses in the early stages of development, corresponding to the periods when lateral flexion of the neck (7.5 weeks) and the grasping reflex (9.5 weeks) first develop.

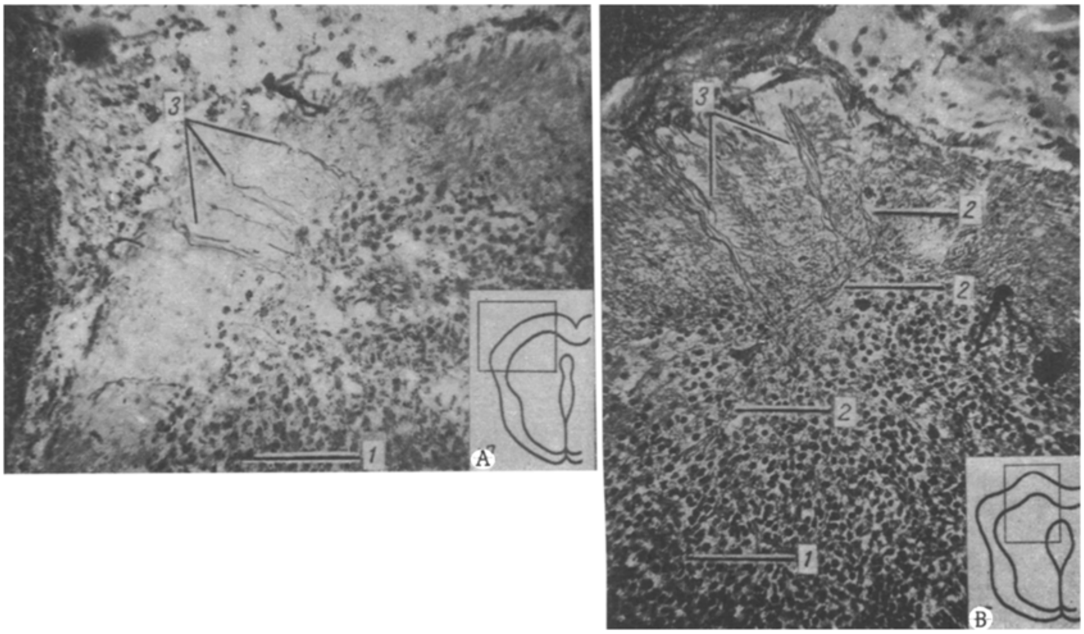

Fig. 3. Presynaptic collaterals of anterior column at level of motor center for digital flexors (8th cervical segment); A) fetus of $7^1/_2$ weeks (no collaterals); B) fetus of $8^1/_2$ weeks (appearance of collaterals); 1) region of center for digital flexors; 2) presynaptic collaterals; 3) root fibers. Peters impregnation method. x 200.

RESULTS

Figure 1 is from a preparation of the anterior cornu of the spinal cord of a 7.5 weeks fetus (CR 20 mm) at the level of the third cervical segment. A compact group of cells, which belong to the spinal nucleus of the accessory nerve, can be distinguished in the posterolateral part of the cornu. A group of delicate fibers, which entered the grey substance and could be traced therein for considerable distances, could be distinguished in the anterior column at the edge of the grey substance. The fibers terminated in the region of the accessory nerve nucleus and spread out fanwise in the vicinity of its cells.

These fibers became more prominent and formed a distinct bundle, running into the grey substance in the direction indicated (Fig. 2A, B), in succeeding stages of development (8.5 weeks, CR 26 mm, and 19 weeks, CR 150 mm).

Similar fibers had not been observed at the level of the eighth cervical segment in 7.5 and 8.5 weeks embryos (Fig. 3A). At 8.5 weeks (CR 26 mm; Fig. 3B), however, there were fibers running from the anterior column into the grey substance towards the motoneurones of the motor center for the digital flexors. These fibers could be readily distinguished from root fibers, as the latter were running in an opposite direction and passed out of the cord through the white substance. Earlier investigations [8, 9] had shown that these fibers in the eighth segment (primary bundle) appeared at about 11 weeks. This difference can be explained by the use of Peters' method, which would appear to be more sensitive in demonstrating fiber structures in the brains of early embryos.

The fact that the times of appearance of these collateral fibers coincided with the order in which the reflexes developed would indicate that these formations are concerned in the structural organization of the reflex arcs. It would therefore appear that cranial structures are involved in lateral flexion of the neck and the grasping reflex right from the time of their development, which means that the central integration of these reflexes is not limited to the spinal cord segments. The ingrowth of the fibers at different times is the result of the selectiveness and unevenness of morphogenetic development, repeatedly noted in the literature [1, 2, 5, 7].

LITERATURE CITED

1. P. K. Anokhin, Byull. Éksp. Biol. Vol. 26, No. 2, p. 81, 1948.
2. P. K. Anokhin, Zh. Obshch. Biol. Vol. 10, No. 5, p. 361, 1949.
3. V. M. Bekhterev, Conducting Pathways of Spinal Cord and Brain (Moscow and Leningrad, 1926).

4. E. L. Golubeva, K. V. Shuleikina, and I. I. Vainshtein, Akush. i Gin. No. 3, p. 59, 1959.
5. E. L. Golubeva, In: Problems of Central Nervous System Physiology and Pathology in the Course of the Ontogenetic Development of Man and Animals. (Moscow, 1961), p. 172.
6. K. V. Shuleikina, Morphophysiological features of development of the grasping reflex in the human embryo. Candidate dissertation (Moscow, 1953).
7. K. V. Shuleikina, Akush. i Gin. No. 4, p. 49, 1958.
8. K. V. Shuleikina, Arkh. Anat. No. 9, p. 14, 1959.
9. K. V. Shuleikina, In: Structure and Function of AnalyzerSystems in the Ontogenetic Development of Man (Moscow, 1961), p. 282.
10. K. V. Shuleikina and N. G. Gladkovich, Proceedings of Fourth Congress of Embryologists (Leningrad, 1963), p. 219.
11. A. W. Angulo y Gonzalez, J. Comp. Neurol. Vol. 71, p. 325, 1939.
12. J. Barcroft and D. H. Barron, Ergebn. Physiol., Vol. 42, p. 107, 1939.
13. A. Brodal, Reticular Formation of Brain-Stem (Moscow, 1960).
14. J. E. Fitzgerald and W. F. Windle, J. Comp. Neurol. Vol. 76, p. 159, 1942.
15. D. Hooker, Psychosem. Med. Vol. 4, p. 199, 1942.
16. D. Hooker, The Prenatal Origin of Behavior (Lawrence, 1952).
17. D. Hooker, Ass. Res. Nerv. Dis. Proc. (1953) Vol. 33, p. 98, 1954.
18. T. Humphrey, J. Comp. Neurol. Vol. 97, p. 143, 1952.
19. T. Humphrey, Ass. Res. Nerv. Dis. Proc. (1953) Vol. 33, p. 127, 1954.
20. T. Humphrey, Arch. Neurol. Psychiat. Vol. 73, p. 36, 1955.
21. T. Humphrey and D. Hooker, J. Comp. Neurol. Vol. 112, p. 75, 1959.
22. O. Larsell, Anatomy of the Nervous System (New York, 1942).
23. M. Minkowski, In: E. Abderhalden: Handbuch der biologischen Arbeitsmethoden (Berlin, 1928), p. 511.
24. W. T. Niemer and H. W. Magoun, J. Comp. Neurol. Vol. 87, p. 367, 1947.
25. J. W. Papez, J. Comp. Neurol. Vol. 41, p. 365, 1926.
26. A. A. Pearson, J. Comp. Neurol. Vol. 68, p. 243, 1938.
27. A. Peters, Stain Technol. Vol. 33, p. 47, 1958.
28. A. Peters, J. Anat. (Lond.) Vol. 93, p. 177, 1959.
29. R. Rhines and W. F. Windle, J. Comp. Neurol. Vol. 75, p. 165, 1941.
30. H A. Riley, An Atlas of the Basal Ganglia, Brain Stem and Spinal Cord. (Baltimore, 1943).
31. A. H. Schultz, Quart. Rev. Biol. Vol. 1, p. 465, 1926.
32. A. A. Ward, In: Reticular Formation of the Brain (Moscow, 1962) [Russian translation], p. 239.
33. W. F. Windle and J. F. Fitzgerald, J. Comp. Neurol. Vol. 67, p. 493, 1937.
34. W. F. Windle, Physiology of the Fetus (Philadelphia, 1940).
35. W. F. Windle, In: P. Weiss (Ed.) Genetic Neurology (Chicago, 1950), p. 214.

All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.
