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Formation of synapses on the growth cones in human embryonic inferior ganglion of the vagus

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Ultrastructural study was performed on inferior ganglia of the vagus in human embryos aged 7 and 8 weeks (developmental stages 18 to 23, 44 to 56 days). The growth cones are observed between the bundles of axons of the inferior ganglia of the vagus. Many primitive synapses (protosynapses) between dendritic and axonal growth cones are observed.

key words: human neuroembryology, inferior ganglion of vagus, growth cone, protosynapses

INTRODUCTION

Growth cones are structurally and functionally different from the normal cytoplasm of the neurone and they are guided by different mechanisms [3, 11]. They are very important in the development of the nervous system because they are responsible for guiding the growing neurite to its target site. They also recognise the target site and are important in the synaptic membrane [4, 6]. Growth cones are the highly motile expansions at the tips of growing and regenerating axons and dendrites [4].

The aim of the present study is to describe the growth cones and to trace the formation of synapses in the inferior ganglion of the vagus at the end of the embryonic period. This time of development is characterised by an intensive formation of the synaptic junctions [2, 7, 8, 18].

MATERIAL AND METHODS

Investigations were made on the inferior ganglion of the vagus nerve of embryos aged 7 and 8 weeks (developmental stages 18 to 23, 44 to 56 days). Inferior ganglia of the vagus were immersed in chilled 1.2% glutaraldehyde for 1 h. The material was then placed for 2 h in 2% glutaraldehyde buffered to pH 7.4 with cacodylate. After washing in cacodylate buffer pieces of ganglia were fixed in 1% osmium tetroxide for 1 hour. Thin and semithin sections were made on Reichert ultramicrotome. Semithin sections were stained with toluidine blue and thin sections were rendered contrasted with uranyl acetate and lead citrate. Thin sections were examined in Opton EM10 and JEM-7 electron microscopes.

RESULTS

In the investigated embryos the inferior ganglia of the vagus are composed of ganglionic cells, glial cells and bundles of axons. Nerve processes are separated by endoneurial spaces containing collagenous fibres and fibroblasts (Fig. 1–3).

At the end of the embryonic period many immature synapses are observed. In the investigated ganglia the growth cones are evident between axons. They appear as large profiles containing mitochondria, neurotubules, neurofilaments, cisternae of smooth endoplasmic reticulum and growth cone vesicles. Each growth cone has a thin distal region with lamellipodia and/or filopodia and the proximal region filled with organelles. The growth cone vesicles occupy the central region of the growth

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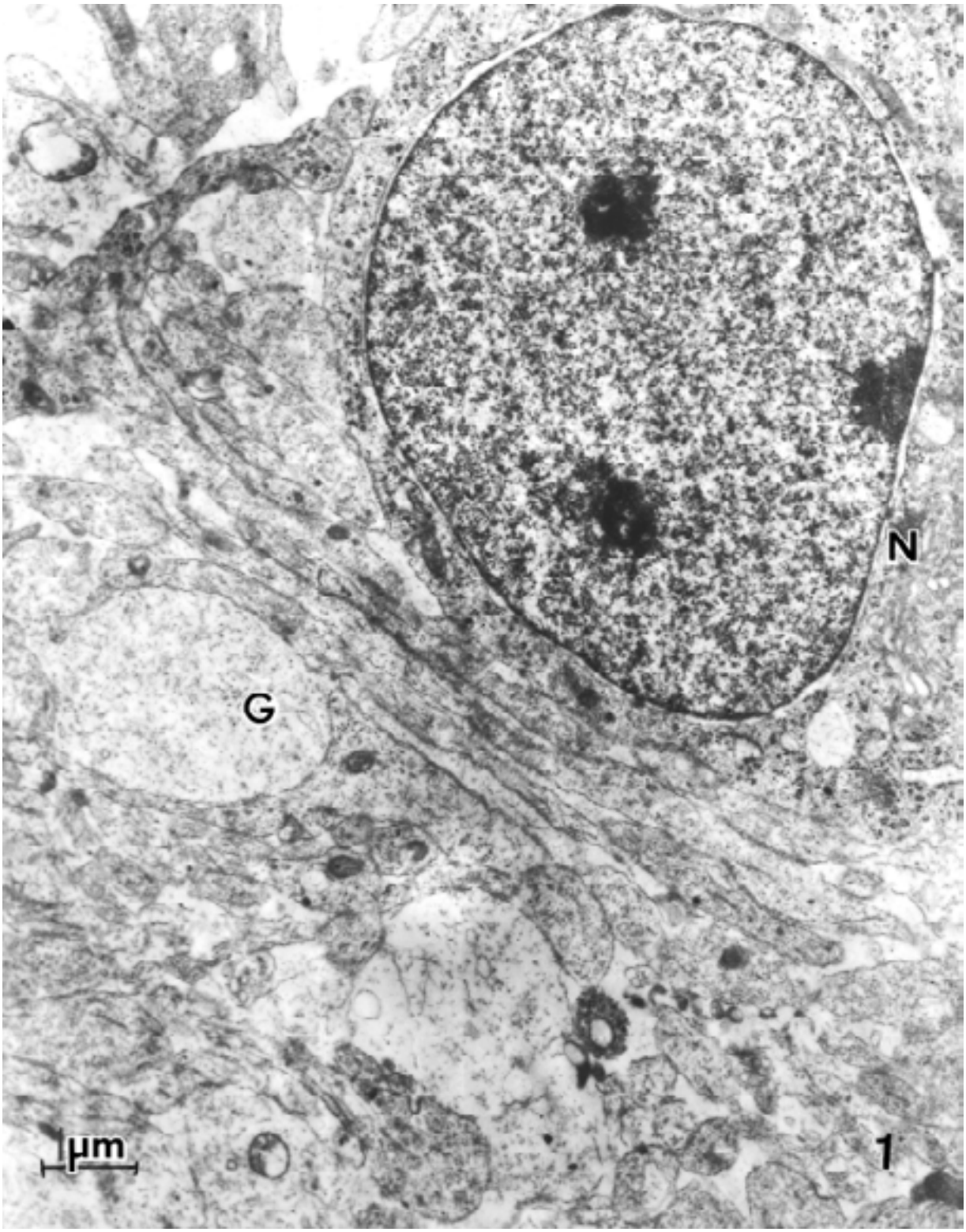

Figure 1. Part of inferior ganglion of vagus in embryo at stage 22; G — growth cone, N — neurone.

cone. The axonal and dendritic growth cones are similar.

Protosynapses or primitive synapses are found on the growing nerve endings, which are called dendritic and axonal growth cones. They consist of thick presynaptic and postsynaptic membranes without an evident synaptic cleft (Fig 2). Formation of synapses is preceded by surface specialisations, which

Figure 2. Growth cones (G) and protosynapse (P) in inferior ganglion of vagus in embryo at stage 23.

are on the periphery of the growth cones. They are small patches of electron-dense material adhering to the surface membrane. The first protosynapses were observed in the inferior ganglion of the vagus in embryos at stage 18 (44 days). The synaptic vesicles are at a certain distance from the presynaptic membrane. These synapses are formed between the axonal and dendritic growth cones.

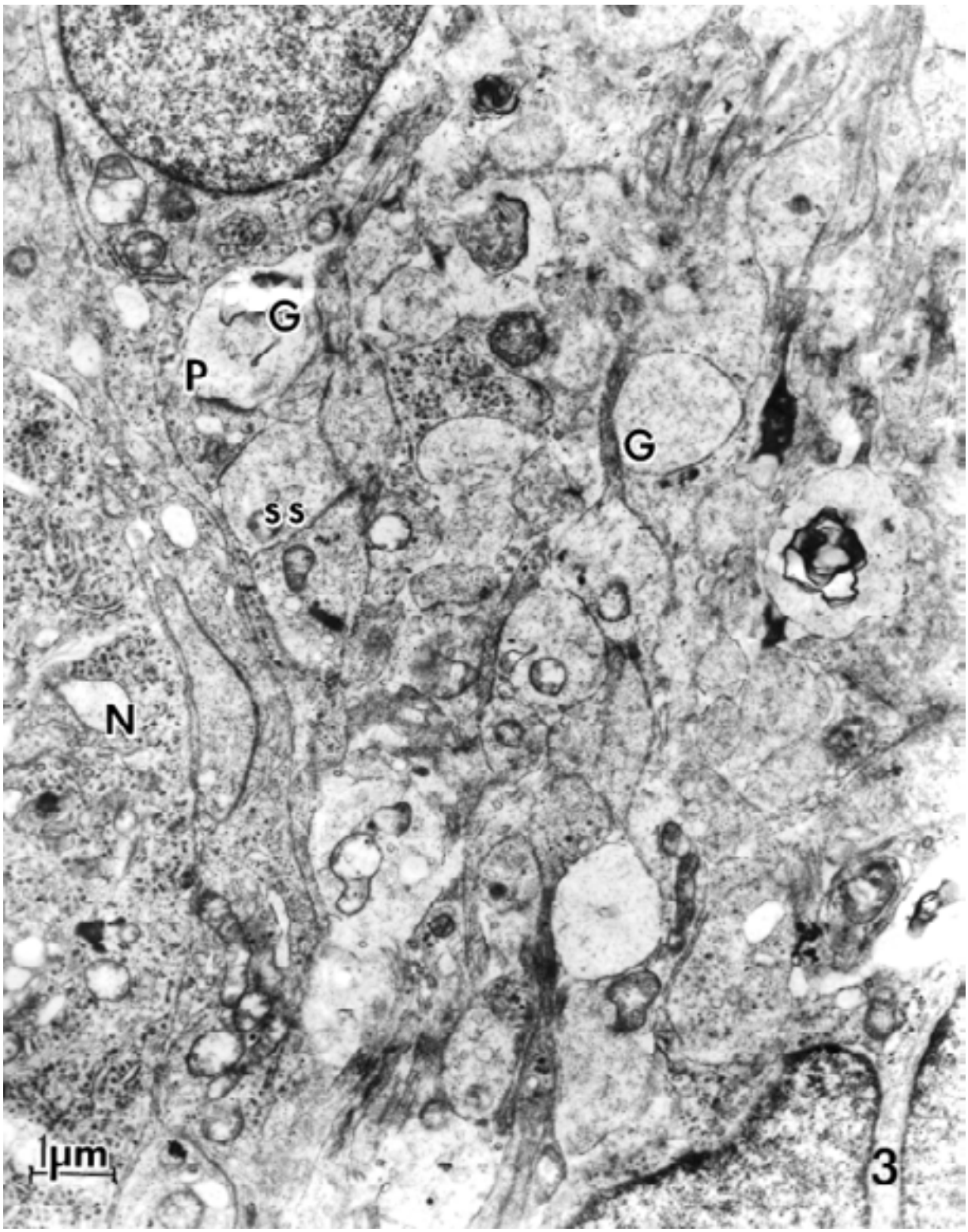

Figure 3. Part of inferior ganglion of vagus in embryo at stage 23; G — growth cone, N — neurone, P — protosynapse, ss — surface specialisations.

DISCUSSION

Neuronal growth cones traverse distances along appropriate pathways to find their correct targets [3]. They determine the direction and pattern of neurite growth [11].

Studies of cytoplasmic signalling mechanisms have shown that the response of a growth cone to a particular guidance cue depends on the internal state of the neurone, which is under the influence of other signals received by the neurone [5, 10]. Axonal growth cones may be distinguished from dendritic growth cones on the basis on their overall morphology and their cytoplasmic components. The axonal growth cone is larger and has a more irregular structure than the dendritic terminal [9, 19].

The development of early synapses in human begins in the 7th week of the embryonic period. There are no descriptions of synaptic junctions in the developing inferior ganglion of the vagus. Early synapses develop between the dendritic growth cones and the axonal collaterals which form the presynaptic elements [12–17]. The early synaptic junctions are preceded by the surface specialisations of neuronal processes [15].

The performed study has shown that at the end of the embryonic period the synaptic junctions are still premature in the inferior ganglion of the vagus. The structure of the growth cones in the inferior ganglion of the vagus resembles that of the superior cervical sympathetic ganglion and the spinal cord [1, 19, 20].

REFERENCES

1. Bruska M (2001) Growth cones in the superior cervical sympathetic ganglion in human foetus aged 23 weeks. Folia Morphol, 60: 285–292.
2. Fitzgerald JE, Winde WF (1942) Some observations on early human fetal movements. J Comp Neurol, 76: 159–167.
3. Goodman CS (1996) Mechanisms and molecules that control growth cone guidance. Ann Rev Neurosci, 19: 341–377.
4. Gordon-Weeks PR (1987) The cytoskeleton of isolated, neuronal growth cones. Neuroscience, 21: 977–989.
5. Klostermann S, Bonhoeffer F (1996) Investigations of signaling pathways in axon growth and guidance. Perspect Dev Neurobiol, 4: 237–252.
6. Landis S C (1983) Neuronal growth cones. Ann Rev Physiol, 45: 567–580.
7. Molliver M, Kostovic I, Van der Loos H (1973) The development of synapses in cerebral cortex of human fetus. Brain Res, 50: 403–407.
8. Okado N, Kakimi S, Kojima T (1979) Synaptogenesis in the cervical cord of the human embryo: Sequence of synapse formation in a spinal reflex pathway. J Comp Neurol, 184: 491–518.
9. Skoff R P, Hamburger V (1974) Fine structure of dendritic and axonal growth cones in embryonic chick spinal cord. J Comp Neurol, 153: 107–148.
10. Song H, Poo M (1999) Signal transduction underlying growth cone guidance by diffusible factors. Curr Opin Neurobiol, 9: 355–363.
11. Tessier-Lavigne M, Goodman CS (1996) The molecular biology of axon guidance. Science, 274: 1123–1133.
12. Vaughn JE, Grieshaber JA (1973) A morphological investigation of an early reflex pathway in developing rat spinal cord. J Comp Neurol, 177–210.
13. Vaughn JE, Henrikson CK, Grieshaber JA (1974) A quantitative study of synapses on motor neuron dendritic growth cones in developing mouse spinal cord. J Cell Biol, 60: 664–672.
14. Vaghn JE, Henrikson CK, Chernow CR, Grieshaber JA, Wimer CC (1975) Genetically-associated variations in the development of reflex movements and synaptic functions within an early reflex pathway of mouse spinal cord. J Comp Neurol, 161: 541–554.
15. Vaughn JE, Henrikson CK, Wood JG (1976) Surface specializations of neuritis in embryonic mouse spinal cord. Brain Res, 110: 431–445.
16. Vaughn JE, Sims TJ, Nakashima M (1977) A comparison of the early development of axodendritic and axosomatic synapses upon embryonic mouse spinal motor neurons. J Comp Neurol, 175: 79–100.
17. Vaughn JE, Sims TJ (1978) Axonal growth cones and developing axonal collaterals from synaptic junctions in embryonic mouse spinal cord. J Neurocytol, 7: 337–363.
18. Windle WF, Fitzgerald JE (1937) Development of the spinal reflex mechanism in human embryos. J Comp Neurol, 67: 493–509.
19. Węclewicz K, Woźniak W (1983) Axonal and dendritic growth cones in the developing human spinal cord. Folia Morphol, 42: 69–72.
20. Woźniak W, Bruska M (1996) Ultrastructural study on axonal and dendritic growth cones in the human embryonic spinal cord. Folia Histochem Cytobiol, 34: 89–90.