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MORPHOMETRIC STUDY OF ISOLATED DOGIEL TYPE II CELLS OF THE INTERMUSCULAR PLEXUS

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Ramilya Babaeva

Department of Human Anatomy and Medical Terminology, Azerbaijan Medical University, Baku, Azerbaijan

✉ *ramilababayeva@mail.ru*

ABSTRACT — Aim of the study was to calculate the morphometric parameters of isolated Dogiel type II cells from the intermuscular plexus of the small intestine.
Materials and methods: 3D models of the oval-shaped Dogiel type II cells from the intermuscular plexus of a rat (n = 1) were constructed and studied. Neurocytes were identified by the impregnation method on the frontal and horizontal sections of the wall of the small intestine.
Results: The results showed that the total number of the nodes in the virtual model was 36534, and the mesh elements — 156595. The resulting 3D model of the cell and nucleus was reduced 900 times to obtain a three-dimensional cell and nucleus with absolute dimensions, with a ratio of 1:1 to their true size. The volume of Dogiel type II cell was 2785.11 μm^3, the volume of the nucleus was 647.7 μm^3 and the volume of its perikaryon was 2785.11 μm^3.
Conclusion: Dogiel type II cells from the intermuscular plexus of the rat small intestine has an ovoid shaped three-dimensional structure. These cells are flattened in transverse direction and elongated in longitudinal direction.

KEYWORDS — Dogiel type II cells, intermuscular plexus, small intestine, volume of perikaryon, volume of nucleus.

INTRODUCTION

The vegetative ganglia are a collection of the numerous multipolar neurons. The size of the vegetative ganglia varies significantly. There are large, medium-sized, small and very small (microganglia) ganglia [1].

Dogiel cells, neurons of the autonomic ganglia. There are three types of cells (I–III). Type I cells (efferent neuron with a long axon) are neurons with short dendrites (located within the ganglion). Type II cells (multipolar, afferent neurons) are a neuron with a long neurite and dendrites; the latter go beyond the ganglion, functionally they are the sensitive (afferent) neurons. Type III cells (associative, intercalary neurons) are the neurons with a long neurite (can reach other autonomic ganglia), dendrites are short (within one ganglion) [2].

Dogiel type II cells, as suggested by A.S. Dogiel, actually perform a sensory function [2]. Their activity is due to the direct action of serotonin and, possibly, the effect of acetylcholine [3]. It is also possible that there are special functional connections between the neurocytes of the intermuscular and submucosal plexuses [4]. However, the data on the morphometric parameters of Dogiel type II cells of both the intermuscular and submucosal plexuses are extremely contradictory, due to the large number (about 40) of the most typical shape of their perikaryon [5]. Moreover, it is believed that neurocytes in metasympathetic ganglia are flat in structure and their thickness is only a few microns [6].

The aim of this study was to calculate the morphological parameters (volumes of perikaryon and nucleus) of an isolated cell of rat's small intestine.

MATERIAL AND METHODS

The neurocytes of the ganglia of the intermuscular plexus of the small intestine of a mature outbred rat (n = 1) were identified by the universal method of impregnation [7]. After fixing a fragment of the intestinal wall in 10% amethanol formalin (5 days), its frontal and horizontal sections with a thickness of 30.0–40.0 μm were made. Slices with an area of 3.0×5.0 cm were enclosed in Canadian balsam and examined under a 1000DM loess microscope with a digital video system. For morphological analysis, two Dogiel type II cells were selected, visualized on the frontal and horizontal sections of the intestinal wall. The morphometric studies of these cells were carried out in the Ymadei software package, the construction of their 3D models — in the AN5Gs Apace claim v 19.2 software.

RESULTS

The color photographs were taken to assess the volume of the perikaryon and nucleus of isolated Dogiel type II cells located in the frontal and horizontal planes (Fig. 1).

Then the photographs were converted into the BMP raster image format (3DtooLR software environment). The sections of neurocyte bodies located in frontal and horizontal sections were separately cut from these images (Fig. 2).

The resulting images were first combined in a Cartesian coordinate system, and then, after aligning

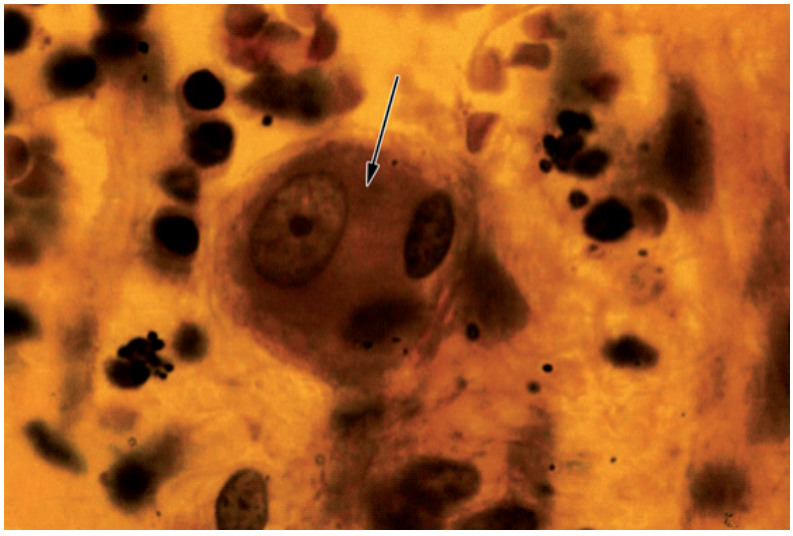

Fig. 1. *Dogiel type II cell in the horizontal plane. A universal method of impregnation. Sw.× 900*

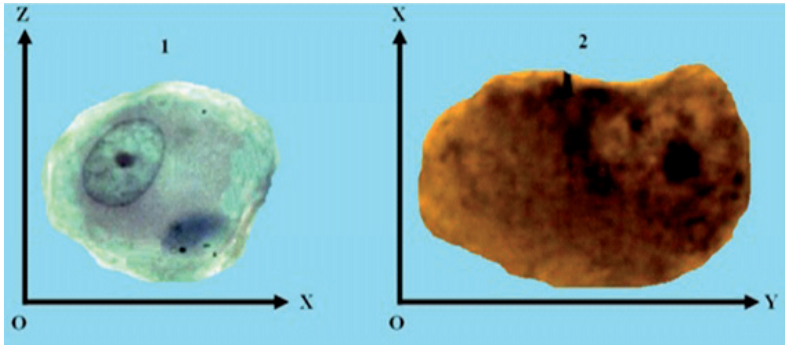

Fig. 2. *Morphometric characteristics of Dogiel type II cells in the Cartesian coordinate system 1) section in the xOz plane; 2) a section in the xOy plane*

the planes and transforming them into a Stl file, into a solid model (in the AutodeskR software environment). The total number of the nodes in the virtual model of Dogiel type II cell was 36534, and the mesh elements were 156595. The resulting 3D model of the cell and nucleus was reduced 900 times in order to obtain a three-dimensional cell and nucleus with absolute dimensions, with a ratio of 1:1 to their true dimensions (Fig. 3).

In the calculations, a number of assumptions were made: 1) the section of the cell in horizontal plane was approximated to a regular shape; 2) the distance between the sections is 0.1% of the cell volume; 3) the material of the investigated volume is isotropic.

The object of the research, the body of the cell H, the overall characteristics of which had to be calculated, is located between two arbitrary planes.

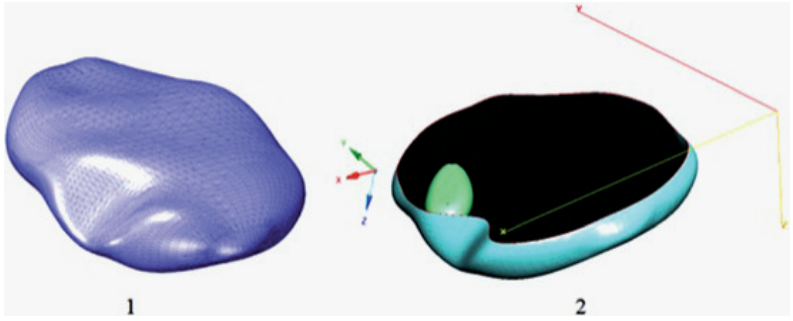

Fig. 3. *Solid-state model of Dogiel type II cell 1) actinometric image; 2) horizontal section of the cell*

The coordinate system is built so that the Ox axis is perpendicular to a and b planes. Letters a and b denote the abscissas of the points of intersection of Ox axis with these planes (a < b). We assume that the body of the cell H is such that its section ϕ (x) is a plane passing through a point with an abscissa (x) and perpendicular to the axis (Ox). Thus, they are an ellipse.

The method used in calculating the volume of the cell consisted in separation of its cross-section into separate areas and in calculating the area of each of them with the subsequent addition of the results.

The following results were obtained: the volume of Dogiel type II cell was 2785.11 μm^3, the volume of the nucleus was 647.7 μm^3, the volume of its perikaryon was 2785.11 μm^3, and the volume of the nucleus was 647.7 μm^3.

DISCUSSION

When studying physiological and pathological processes in biological systems, it will be essential to employ cybernetic principles [8]. It must be admitted that *the pathological process is too complicated to solve its nature without the help of mathematics*. In this regard, at present, the most promising method for the study of histological material is CAE technologies. Moreover, the reconstruction of a neurocyte, due to the complexity of its morphology, requires from 2000 to 3000 measurements of its various parameters [9]. At the same time, it is recognized that the morphometric parameters of the intestinal neurocytes of humans and dogs are practically the same. In the literature, studies of the morphometric parameters of various cells, including neurocytes, using *manual* counting are presented [10]. For this, in some cases, the large and small diameters of the perikaryon and nucleus were measured, and their volumes were calculated using the ellipsond formula (V = Pa2v) [11]. In other cases, the volume of the perikaryon and the nucleus was found by the formula: V = av2; where a — large diameter, b — small diameter. In third cases, the cell volume was determined by the formula V = a2b, in spherical nuclei — V = D30.52, ellipsoidal nuclei — V = (a + b) 2 0.07 [12]. In all cases, there is a few number of the measurements with a "manual" method of counting and their relative low accuracy [10].

FINDINGS

1. The Dogiel type II cell from the intermuscular plexus of the rat's small intestine has an ovoid shaped three-dimensional structure.

2. The cell is flattened in transverse direction and elongated in longitudinal direction.

REFERENCES

1. **Kolosov, N.G.** Structural organization of vegetative ganglia / N.G. Kolosov, A. Ya. Khabarov. N – Leningrad: – Science, – 1978 . – 72 p.
2. **Drachev, A.D.** The pride of St. Petersburg University is Alexander Stanislavovich Dogiel // Morphology, – 2002, – No 5, – pp. 9–11.
3. **Tolkunov, Yu.A.** Sensory neurons of metasympathetic (intramural) ganglia of the small intestine of a guinea pig // Russian Journal of Physiology. THEM. Sechenov, – 2004, – No. 2, – p. 221–229.
4. **Costa, M.** Anatomy and physiology of the cuteric nervous system / M. Costa, S. J. H. Brookes, J. W. Hennig // Yut, – 2000, – Vol. 47, – P. 15–19. DOI: 10.1136/gut.47.suppl_4.iv15
5. **Song, Z.M.** Projections of submucous neurons to the myenteric plexus in the guinea pig small intestine / Z.M.Song, M.Costa, S.J.Brookes // J. Comp Neurol. 1998, No 21; 399 (2), p. 255–268. DOI: 10.1002/(sici)1096-9861(19980921)399:2<255::aid-cne8>3.0.co;2-#
6. **Koshev, V.I.** Autonomous afferent innervation of the muscular membrane of the gastrointestinal tract / Structural bases of innervation and vascularization of skeletal muscles and muscular membrane of hollow organs of mammals and humans. – Samara, – 2010, – p. 110–121.
7. **Markov, I.I.** A universal method for the selective detection of argyrophilic structures / I. I. Markov, E. S. Petrov, V. I. Markova // Morphological statements, – 2016, – No. 1, – p. 116–119.
8. **Berendeev, N.N.** Methods for solving fatigue problems in the ANS WORKBENCH package // Teaching aid. N. Novgorod, – 2012, – 64 p.
9. **Teltsov, L. P.** Morphogenesis of nervous tissue in the wall of the colon in cow embryos and in newborn calves / LP Teltsov, EV Kizim // Morphological statements, – 2002, –No 1–2, – pp. 43–47.
10. **Fofanova, K.A.** The synthesis phase of the neurosecretory cycle and the quantitative assessment of activity and neurons of the supraoptic nucleus of the rat hypothalamus // Archives of Anatomy and Histology, – 1974, – No 7, – p. 83–89.
11. **Israilov, B.** Morphometric characteristics of jejunal neurons in an aging organism / B. Israilov, VR Mayorov, NL Soloviev // Archives of Anatomy and Histology, – 1976, – No. 5, – p. 53–56
12. **Andreev S.Yu.** Influence of the preparation of ginseng tissue culture on morphofunctional changes in motor neurons upon their activation / S.Yu. Andreev, E.M. Zamoskovsky // Archives of Anatomy and Histology, – 1981, – No. 9, – p.34–40.
13. **Fung C., Berghe P.V.** Functional circuits and signal processing in the enteric nervous system// Cell Mol Life Sci, – 2020, 77(22):4505–4522. doi: 10.1007/s00018-020-03543-6.