ORIGINAL PAPER

Enteric nervous system development in cavitary viscera allocated to the celiac plexus

ALINA MARIA ŞIŞU[1)], CODRUŢA ILEANA PETRESCU[1)], C. C. CEBZAN[1)], M. C. NICULESCU[1)], V. NICULESCU[1)], P. L. MATUSZ[1)], M. C. RUSU[2)]

[1)]*Department of Anatomy and Embryology, "Victor Babeş" University of Medicine and Pharmacy, Timisoara*

[2)]*Department of Anatomy and Embryology, Faculty of Dental Medicine, "Carol Davila" University of Medicine and Pharmacy, Bucharest*

Abstract

Enteric nervous system (ENS) is a network made of neuronal cells and nervous fibers. There are two plexuses: myenteric of Auerbach and sub mucous of Meissner and Henle. Many substances are involved in neurotransmission at ENS level. ENS assures all gastrointestinal system functions: digestion, absorption, etc. Our study is made on 23 human fetal specimens at different ages of evolution with crown-rump lengths from 9 to 28 cm, and three new born human specimens. We used the Trichrome Masson stain technique and the argental impregnation Bielschowsky on block technique for microscopic evidence. Our study concerned the cavitary viscera allocated to the celiac plexus, involving all layers of each studied viscera.

***Keywords*:** viscera, neurons, celiac plexus, argental impregnation.

Introduction

The enteric nervous system (ENS) is from morphological and neurochemistry point of view a real "brain". At a complex network level made from neurons and nervous fibers we find much more neurotransmitters and neuromodulaters than anywhere in peripheral nervous system [1]. This structure allows ENS to accomplish its functions without a control from central nervous system. ENS is a collection of neurons at the gastrointestinal system level [2], forming "the intestinal brain" and can be functioning independent from central nervous system. The best hypothesis is that ENS can be considering a migrating portion of central nervous system, which keeps the communication with the last through sympathetic and parasympathetic neurons, afferents and efferent. The part of central nervous system connected to enteric neurons is described like an autonomic central nervous network [3].

Neural and glial precursors of ENS are descendents of neural crest migrated cells [1, 4]:

- the vagal crest has the main contribution because its cells is colonizing the whole intestine;
- the rostral crest of the trunk is colonizing only the esophagus and the proximal portion of the stomach;
- the sacral crest is colonizing postombilicaly intestine.

The majority of nervous fibers, which innervated the intestine, have origin from the intrinsic plexuses. Mainly are two ganglia plexuses interconnected, Auerbach myenteric plexus, with location between the longitudinal and circular muscular layers and sub mucous plexus (Meissner and Henle) between the circular muscle and mucous muscle layer.

The ultra structural studies show that the ENS structure is closer to the central nervous system than the sympathetic and parasympathetic ganglia [5–7]. Glial cells and neurons are interconnected its processes are making a dense neuropile. It was demonstrated a hematoganglia border, analogous to the hematoencephalical one.

After birth, the number of neurons from central nervous system is increasing but in ENS, that number is decreasing [5–8].

It was found eight morphological types of ENS neurons, but two are mainly: type I neurons with many processes as bludgeon-like and one long thin process; type II neurons, multipolars, with many long and smooth processes [2, 9].

Material and methods

The present study was made in the anatomy lab on three new born and 23 human fetal specimens with crown-rump lengths from 9 to 28 cm. On these specimens was studied the macroscopic and mezoscopic configuration of the viscera allocated to the celiac plexus wall.

It was used the argental impregnation by Bielschowsky on block and Trichrome Masson methods for light microscopy.

Results

At 19 weeks of pregnancy at the gastric wall level we remarking the presence of a morphological relative unitary population, forming by cells with primary neuronal aspect, characterized by abundance and missing groups organization. It is intramural plexiforme elements [10–12].

A sagittal section of gastric wall (Figure 1) shows from the outer to inner layers (left to right): the serous (with longitudinal vessels having erythrocytes in lumen); muscular layers (longitudinal and circular, separates by a connective tissue full of cells group with neuronal aspect); sub mucous layer and mucous muscle. In sub mucous layer are present dense group of nervous cells (3–10) at equal distance, corresponding the Meissner–Henle sub mucous ganglia (black arrows). Also, is present rarefied nervous cells group but better numeric represented (blue circle). Detailing the sub mucous ganglia at 5-fetal-months it can see sub mucous dense units formed by variably size cells types, in direct correlation with individual amount of cytoplasm. These cells emits fine shorts prolonged, composing in the group periphery a large polygonal size plexus.

The transverse section of gastric wall at human fetus of 20 cm crown-rump lengths presents multiple locations of consistent populations, composed by neuronal primary cells, ovals or mitrals.

Its prolonged are local intricate, conforming locally ganglia plexuses: outer from circular muscle layer (blue circle); between circular muscular layer and longitudinal muscle fascicles (black circle) and intricate with deep longitudinal muscular fascicles (red circle) (Figure 2).

After birth the neurons of myenteric plexus are numeric reshaped (Figure 3) correlated with morphological definition of these cells, in the plexus still thin in this stage of development.

Discussions

Numeric shaping of serous ganglia is obvious until 21-fetal-weeks to birth [13]. Twenty-first-weeks fetus presents configured sub serous micro ganglia in the local sub serous plexuses, made of small size neurons 4–7 conglomerated. At birth, the number of neuronal elements from sub serous layer is drastically reduced, in the same time with the increase size of living cells touching with processes the tissue target, being integrated in the control and command circuits.

At pylorus level were found numeric reduced groups of primary neurons between the sphincter circular layers fibers. These cells are interconnected by fine prolonged configuration, forming a rudimentary myenteric plexus with circumpherencial prolonged at each muscular fiber.

Oblique section at gallbladder at 5-fetal-months shows nervous cells abundance, dispersed and intricate with fibroblastic elements. Density and size nervous cells with primary nervous aspect is larger per vascular and on the extrinsic nerves side (at the gallbladder cervix).

Cai WQ and Gabella G (1983) [10] describes the intrinsic nervous configuration in the gallbladder wall at cervix and the results are mainly the same with our observations in fetal human specimens. At newborn per arterial neuronal agglomeration from the outer layer at gallbladder, cervix level is keeping as the nervous cells intraparietal dispersion (keeping the primary aspect).

Rash RM and Thomas MD [13] describes in 1962 the subserous plexus, showing the enteric neurons specialization in type I Dogiel cells-argirophiles with short dendrite and type II Dogiel-argirophiles with less dendrite, but much longer.

The presence at 8-fetal-months a balanced argirophile nervous cells focus in the pylorus to mesenteric edge, and composed by argirophile cells at muscle and sub mucous layers (Figure 4), recommends this type of cells as precursors of type I Dogiel cells, being involved in local activity coordination leading to conclude that in the pregnancy is establish the morphological structures which coordinates the peristaltic. It is controversy the choledoc duct preparations made by argental impregnation (Figure 5).

At 8-fetal-months, many nervous cells equally distributed in the circumpherence (Figure 6), meantime Lázár L and Maros T (1978) [14] are not agreed. They found on the rabbits study and human fetuses by argental impregnation the nervous plexus without the nervous cells presence.

Conclusions

The results are the following:

- In the stomach the enteric plexus ganglia system is obvious since 5-fetal-months in all muscular layers.
- The pylorus is forming only in muscular layer at 5-fetal-months the plexus. Pyloric neurons are disposed in bands. At birth and after it's forming the enteric micro ganglia.
- The gallbladder at 5-fetal-months has a dispersed population, immature but very numerous. At 8-fetal-months it decreases, maturates but still dispersed; at newborn is disposed only as a neuronal focus.
- At the choledoc duct level at 8-fetal-months does not exists a plexus. The argirophiles neurons appear as dispersed and at newborn choledoc are intramural ganglia.
- Argirophile cells elements seen at 8-fetal-months are morphologic correlated with type I Dogiel cell, with local intramural viscera activity coordination. These elements are defined before birth and assure the morphological support for sustained a sensitive secretor activity and a good motility.

References

[1] GERSHON M. D., *V. Genes, lineages, and tissue interactions in the development of the enteric nervous system*, Am J Physiol, 1998, 275(5 Pt 1):G869–873.
[2] FURNESS J. B., COSTA M., *Types of nerves in the enteric nervous system*, Neurosci, 1980, 5(1):1–20.
[3] GOYAL R. K., HIRANO I., *The enteric nervous system*, N Engl J Med, 1996, 334(17):1106–1115.
[4] GERSHON M. D., ERDE S. M., *The nervous system of the gut*, Gastroenterology, 1981, 80(6):1571–1594.
[5] GABELLA G., *Fine structure of the myenteric plexus in the guinea-pig ileum*, J Anat, 1972, 111(Pt 1):69–97.
[6] GABELLA G., *Neuron size and number in the myenteric plexus of the newborn and adult rat*, J Anat, 1971, 109(Pt 1):81–95.

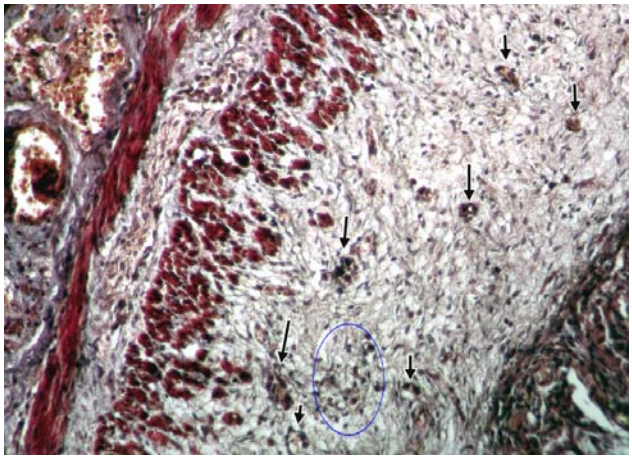

Figure 1 – ***Well configured sub mucous ganglia at 21-fetal-weeks. Transversal section at stomach level; 20 cm crown-rump lengths human fetus (Trichrome Masson, ×200)***

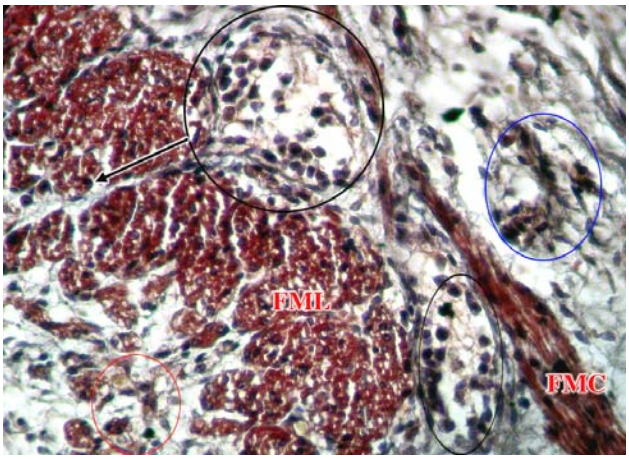

Figure 2 – ***Transversal section at stomach level. 20 cm crown-rump lengths human fetus (Trichrome Masson, ×400). Myenteric ganglia between the circular and longitudinal layers (black circle) and outer of circular layer (red circle)***

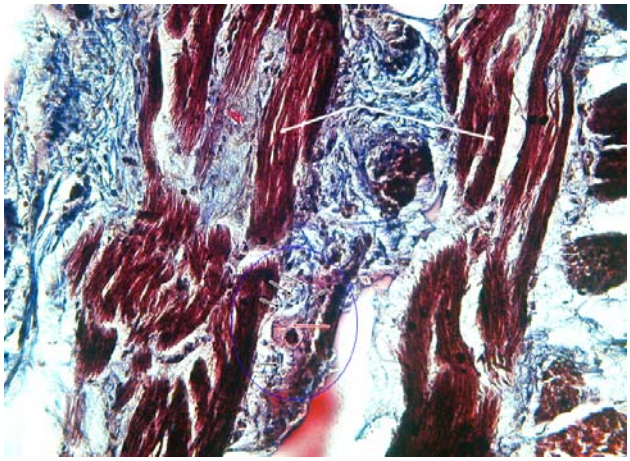

Figure 3 – ***Gastric myenteric neuron. New born (Trichrome Masson, ×1000). Neuronal morphology defined in a fine myenteric fibrilar plexus***

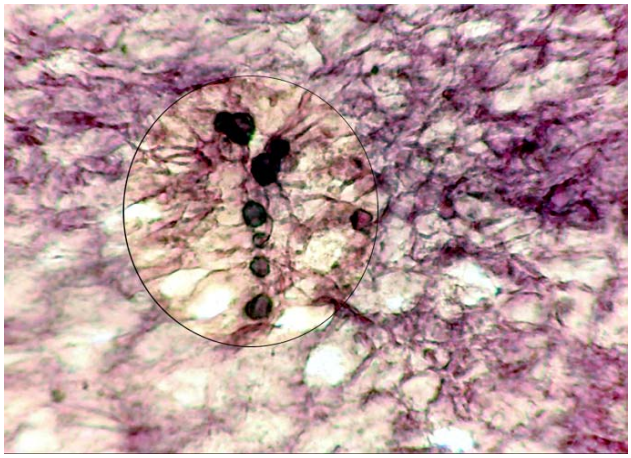

Figure 4 – ***Transversal section at pylorus level. Argental impregnation (Bielschowsky on block), ×630. Primary argirophile cells (Dogiel I). Nuclear morphology suggesting possibility the diagnostic of Cajal interstitial cells (precursors)***

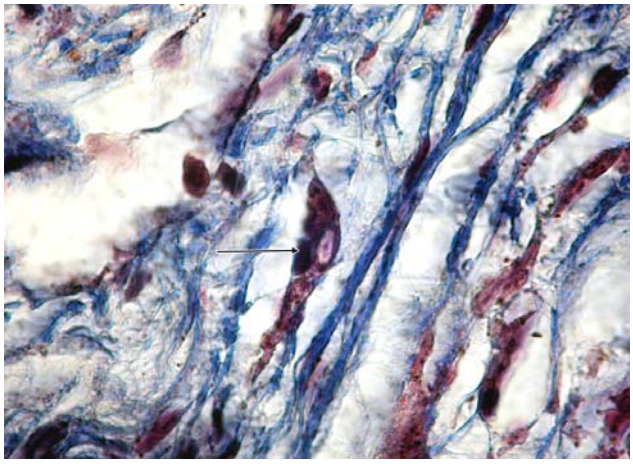

Figure 5 – ***Transversal section at pylorus level. New born (Trichrome Masson, ×1000). Submucous ganglia***

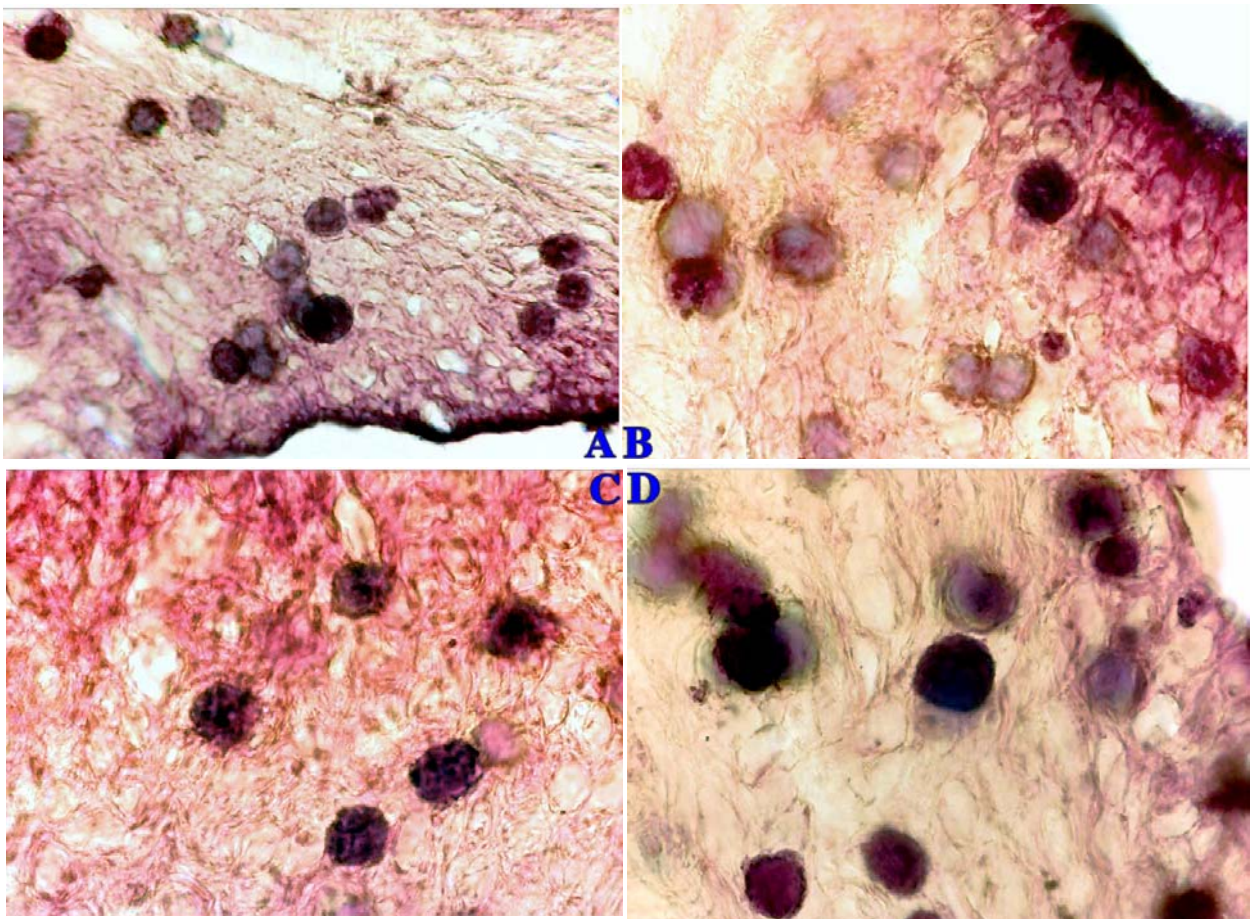

Figure 4 – ***Transversal section at choledoc duct level; 28 cm crown-rump lengths human fetus. Argental impregnation (Bielschowsky on block), ×630 (A), ×1000 (B–D). Disposition in wall of the choledocal nervous cells***

[7] GABELLA G., TRIGG P., MCPHAIL H., *Quantitative cytology of ganglion neurons and satellite glial cells in the superior cervical ganglion of the sheep. Relationship with ganglion neuron size*, J Neurocytol, 1988, 17(6):753–769.

[8] ALTMAN J., DAS G. D., *Autoradiographic and histological studies of postnatal neurogenesis. I. A longitudinal investigation of the kinetics, migration and transformation of cells incorporating tritiated thymidine in neonate rats, with special reference to postnatal neurogenesis in some brain regions*, J Comp Neurol, 1966, 126(3):337–389.

[9] COSTA M., BROOKES S. J., *The enteric nervous system*, Am J Gastroenterol, 1994, 89(8 Suppl):S129–S137.

[10] CAI W. Q., GABELLA G., *Innervation of the gall bladder and biliary pathways in the guinea-pig*, J Anat, 1983, 136(Pt 1):97–109.

[11] HILLS J. M., JESSEN K. R., Transmission: gamma-amino butyric acid (GABA), 5-hydroxytryptamine (5-HT) and dopamine. In: BURNSTOCK G., HOYLE C. H. V. (eds), *Autonomic neuroeffector mechanisms*, Harwood Academic Publishers, Switzerland, 1992, 465–507.

[12] JESSEN K. R., BURNSTOCK G., The enteric nervous system in tissue culture: a new mammalian model for the study of complex nervous networks. In: KALSNER S. (ed), *Trends in autonomic pharmacology*, II[nd] volume, Urban and Schwartzenberg, Baltimore, 1982, 95–115.

[13] RASH R. M., THOMAS M. D., *The intrinsic innervation of the gastro-oesophageal and pyloro-duodenal junctions*, J Anat, 1962, 96:389–396.

[14] LÁZÁR L., MAROS T., *Data regarding the structural feature of nervous elements in the bile ducts during intrauterine life*, Morphol Embryol (Bucur), 1978, 24(3):203–206.

Corresponding author
Alina Maria Şişu, Assistant, MD, PhD, Department of Anatomy and Embryology, "Victor Babeş" University of Medicine and Pharmacy, 2 Eftimie Murgu Square, 300 041 Timişoara, Romania; Phone +40724–361 671, E-mail: alinasisu@gmail.com

Received: July 25th, 2007

Accepted: October 20th, 2007