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Differentiation of the facial-vestibulocochlear ganglionic complex in human embryos of developmental stages 13–15

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A study was made on 18 embryos of developmental stages 13–15 (5th week). Serial sections made in horizontal, frontal, and sagittal planes were stained with routine histological methods and some of them were treated with silver. In embryos of stage 13, the otic vesicle is at the rhombomere 5, and close to the vesicle is the facial-vestibulocochlear ganglionic complex in which the geniculate, vestibular, and cochlear ganglion may be discerned. These ganglia are well demarcated in embryos of stage 14. In the last investigated stage (15th) the nerve fibres of the ganglia reach the common afferent tract. (Folia Morphol 2009; 68, 3: 167–173)

Key words: human neuroembryology, ganglia of 7th and 8th nerves

INTRODUCTION

The study of the embryonic development of the cranial nerve ganglia was concerned with: 1) the derivation of these ganglia, 2) the identity of the placodes from which the ganglia are derived, and 3) the relation of the development of the ganglia to the development of the sensory and motor nuclei within the brainstem [1].

It is evident from morphological and experimental studies that the cranial nerve ganglia originate from the neural crest cells and/or somatic ectoderm (placodes) which arise from a common anlage lying between the neural plate and the epidermis. This anlage could be formed by a mechanism similar to that underlying the initial induction of the neural crest [2].

The geniculate ganglion contains sensory neurons which distribute taste fibres to the anterior tongue and somatic sensory fibres to the external ear. Boudreau et al. [4] showed in the cat that different geniculate ganglion cells responded selectively to stimulation of the tongue and external ear. There has been much debate as to whether the facial ganglion is derived from the neural crest or placode [2, 3, 17, 20, 21].

The vestibular ganglion contains the primary sensory neurons that convey information from the receptors of the labyrinth to the vestibular nuclei. The cochlear ganglion consists of cells that convey information from the receptors of the cochlear duct to the cochlear nuclei.

The origin of cells comprising the facial, vestibular, and cochlear ganglia is still not established [1, 2, 20].

In our previous investigations [5, 6, 19] we described the structure and differentiation of the vestibulocochlear and geniculate ganglia in human embryos. Special attention was paid to the formation of nerve fibres at the ganglia reaching receptor cells and central nuclei.

The present study performed on staged human embryos was concerned with the differentiation of facial, vestibular, and cochlear ganglia in embryos in the 5th week.

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Table 1. CR length, developmental stage, and postovulatory days of investigated embryos

Catalogue number	CR length [mm]	Developmental stage	Age (days)	Plane of section
B202	4.5	13	32	Horizontal
B218	5.5	13	32	Horizontal
B208	5.5	13	32	Frontal
B194	6.0	13	32	Horizontal
B207	6.0	13	32	Frontal
I	5.5	13	32	Sagittal
B195	5.5	14	33	Sagittal
A17	6.5	14	33	Sagittal
A19	7.0	14	33	Frontal
B186	7.0	14	33	Frontal
AS21	7.5	14	33	Horizontal
PJK19	7.0	14	33	Sagittal
A16	8.5	15	36	Sagittal
B75	8.0	15	36	Horizontal
B115	8.0	15	36	Horizontal
B69	9.0	15	36	Sagittal
PJK20	9.0	15	36	Horizontal
B175	9.0	15	36	Frontal

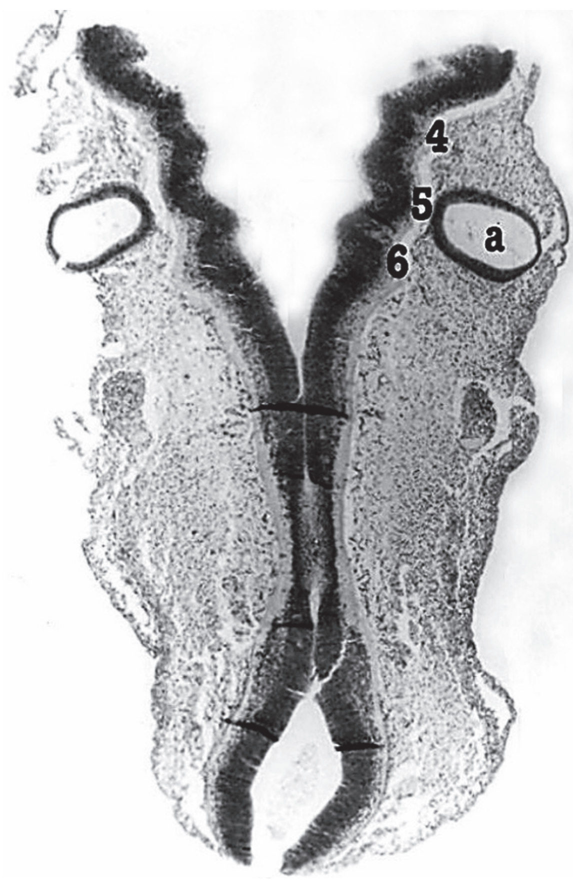

Figure 1. Horizontal section of brain in embryo at stage 13. H + E, × 40; a — otic vesicle; 4, 5, 6 — rhombomeres.

MATERIAL AND METHODS

The study was performed on 18 human embryos at developmental stages 13–15 (postovulatory days between 32 and 36, Table 1). Embryos were from the Collection of the Department of Anatomy, Poznań University of Medical Sciences.

Serial sections of embryos were made in sagittal, frontal, and horizontal planes. Sections were stained according to routine histological methods and impregnated with silver. In some embryos graphic reconstructions were made.

RESULTS

In embryos at stage 13 (32 postovulatory days) the otic vesicle is separated from the surface and lies at the level of the rhombomere 5 (Figs. 1, 2). Anteriorly and ventrally to the vesicle is the facial-vestibulocochlear ganglionic complex (Figs. 3, 4). Neural crest cells migrate from the wall of the vesicle and from the wall of rhombomere 4 (Figs. 5, 6). In the facial-vestibulocochlear complex the geniculate and vestibulocochlear ganglia may be distinguished (Fig. 7).

The geniculate ganglion presents a fusiform structure in the anterior part of the ganglionic complex. Cells of this ganglion are arranged in vertical rows parallel to the course of the facial nerve (Figs. 8, 9).

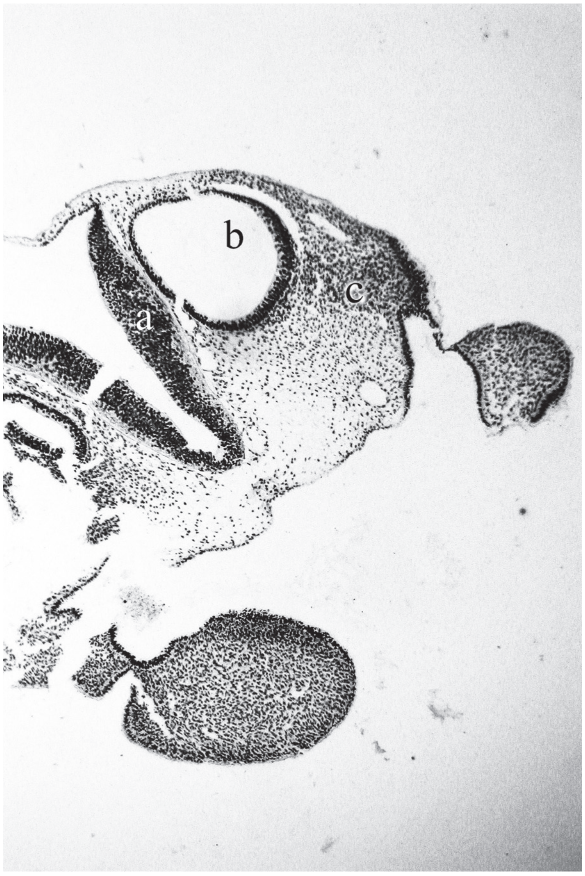

Figure 2. Horizontal section of embryo at stage 13. Bodian's protargol, × 40; a — rhombomere 5, b — otic vesicle, c — facial-vestibulocochlear ganglionic complex.

Figure 3. Horizontal section of head in embryo at stage 13. H + E, × 100; 5 — rhombomere 5, a — otic vesicle, b — vestibulocochlear ganglion, c — geniculate ganglion.

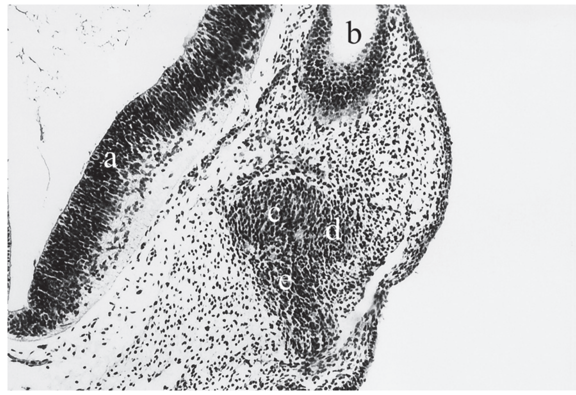

Figure 4. Horizontal section of head in embryo at stage 13. Cresyl violet, × 100; a — rhombomere 4, b — otic vesicle, c — vestibular ganglion, d — cochlear ganglion, e — geniculate ganglion.

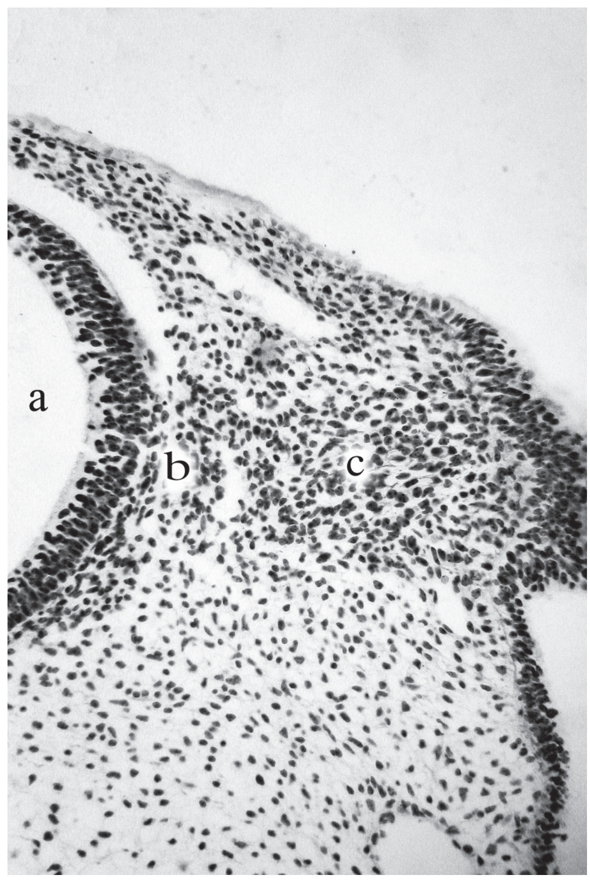

Figure 5. Horizontal section of embryo at stage 13. Bodian's protargol, × 400; a — otic vesicle, b — neural crest cells from the wall of otic vesicle, c — facial-vestibulocochlear ganglionic complex.

It is also possible to differentiate the vestibular and cochlear ganglia.

In embryos at stage 14 (33 postovulatory days) the primordium of the endolymphatic duct is clearly seen (Fig. 10). The geniculate, vestibular, and cochlear ganglia are also well demarcated (Figs. 11, 12). The geniculate ganglion is traversed through nerve fibres and continues as a trunk of the facial nerve. The vestibular ganglion is closely attached to the otic vesicle and is composed of intensively stained

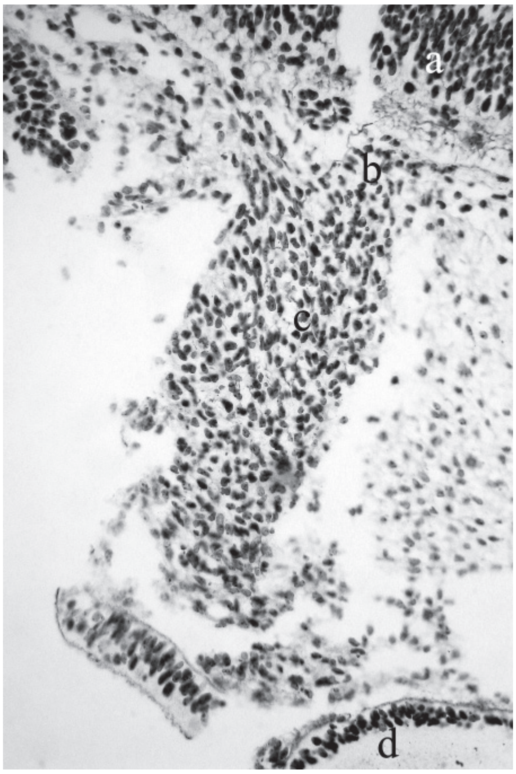

Figure 6. Sagittal section of embryo at stage 13. Cresyl violet, × 400; a — rhombomere 4, b — neural crest cells, c — facial--vestibulocochlear ganglionic complex, d — otic vesicle.

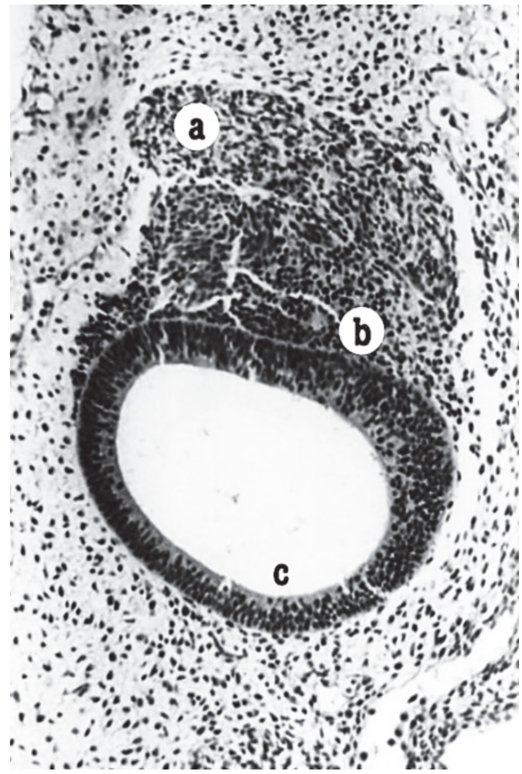

Figure 8. Higher magnification of section presented in Figure 7 (stage 13). H + E, × 200; a — geniculate ganglion, b — vestibulocochlear ganglion, c — otic vesicle.

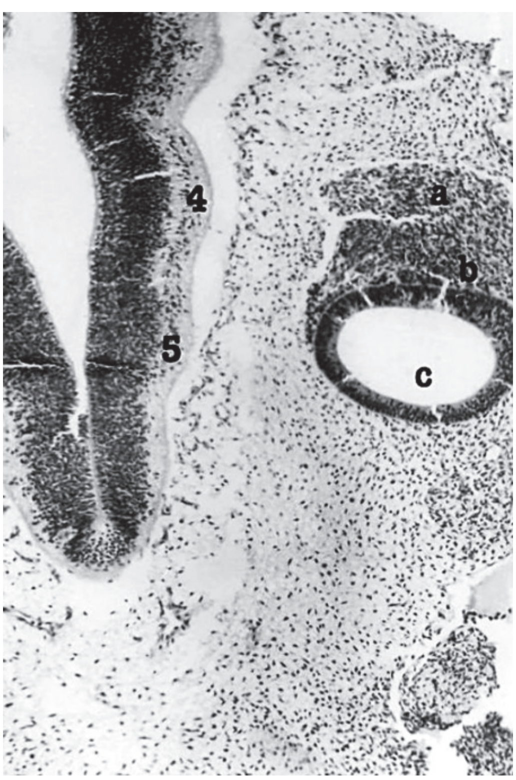

Figure 7. Horizontal section of embryo at stage 13. H + E, × 100; a — geniculate ganglion, b — vestibulocochlear ganglion, c — otic vesicle; 4, 5 — rhombomeres.

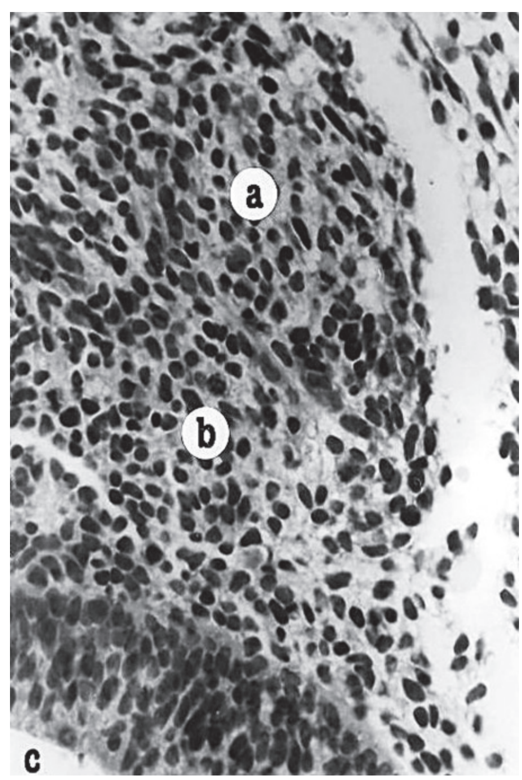

Figure 9. Facial-vestibulocochlear ganglionic complex in embryo at stage 13. H + E, × 450; a — geniculate ganglion, b — vestibulocochlear ganglion, c — wall of otic vesicle.

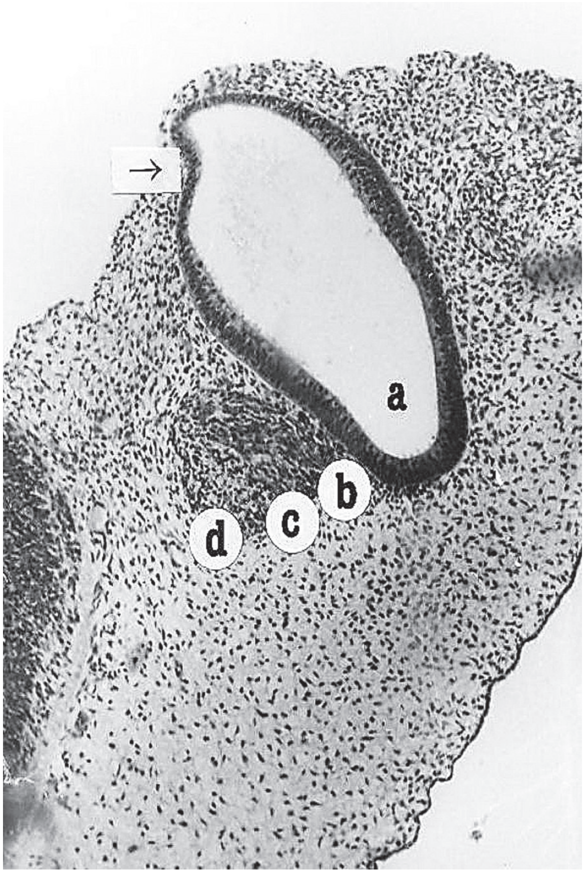

Figure 10. Sagittal section of embryo at stage 14. H + E, × 100; a — otic vesicle, b — vestibular ganglion, c — cochlear ganglion, d — geniculate ganglion, arrow points endolymphatic duct.

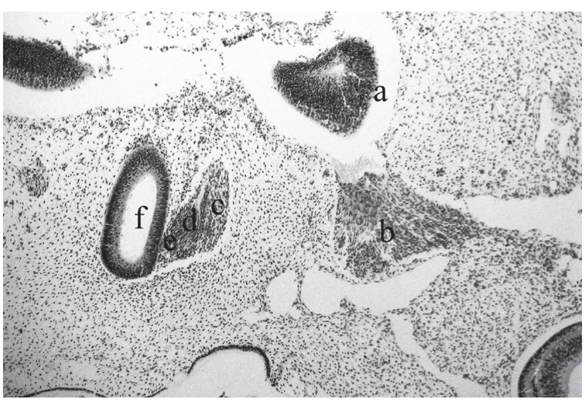

Figure 11. Sagittal section of embryo at stage 14. Bodian's protargol, × 100; a — midbrain, b — trigeminal ganglion, c — geniculate ganglion, d — cochlear ganglion, e — vestibular ganglion, f — otic vesicle.

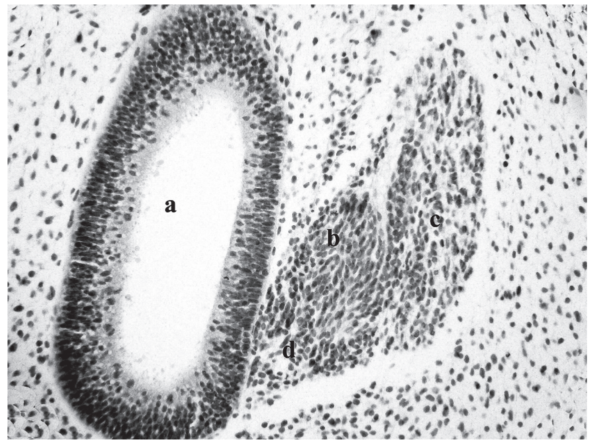

Figure 12. Section as in Figure 11 (stage 14). Bodian's protargol, × 400; a — otic vesicle, b — cochlear ganglion, c — geniculate ganglion, d — vestibular ganglion.

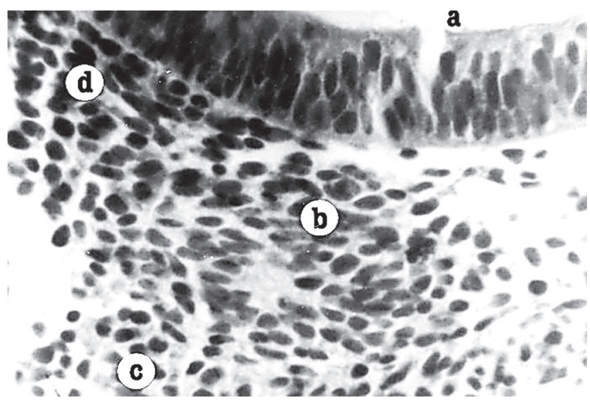

Figure 13. Sagittal section of brain in embryo at stage 14. H + E, × 450; a — otic vesicle, b — cochlear ganglion, c — geniculate ganglion, d — vestibular ganglion.

oval cells which are larger than the cells forming the cochlear ganglion. Cells from the wall of the otic vesicle still migrate to the vestibular ganglion (Fig. 13).

In embryos at stage 15 (36 postovulatory days) the relation of particular ganglia which develop from the ganglionic complex is not markedly changed (Figs. 14, 15). Nerve fibres from all differentiated ganglia extend to the brain stem, and they terminate in the common afferent tract (Fig. 16). In addition, peripheral branches of particular nerves develop. The otic vesicle shifts ventrally and occupies a position opposite rhombomeres 5 and 6.

DISCUSSION

According to the investigations of Gasser [7], a well-defined geniculate ganglion is present in embryos of 11.0 to 13.5 mm length. This length corresponds to developmental stages 17 or 18. His [8] stated that up to the third month no nerve arises between the facial and acoustic ganglia. Streeter [18] found the geniculate ganglion in a 7 mm human embryo. Such a length designates an embryo at stage 14 or 15.

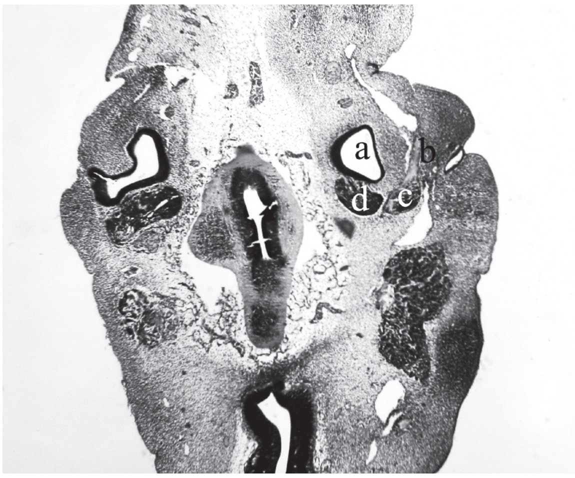

Figure 14. Sagittal section of embryo at stage 15. Cresyl violet, × 40; a — otic vesicle, b — trunk of the facial nerve, c — geniculate ganglion, d — vestibulocochlear ganglion.

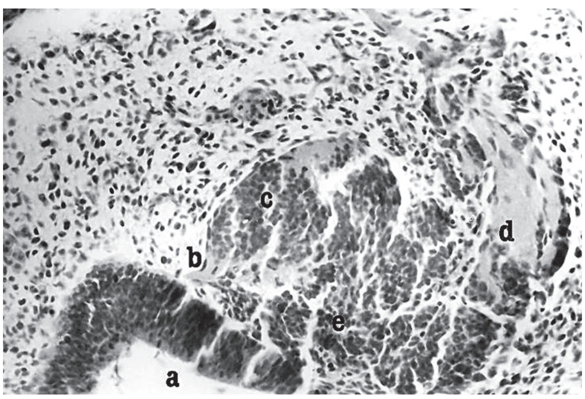

Figure 15. Sagittal section of embryo at stage 15. H + E, × 250; a — otic vesicle, b — dendrites of cells of vestibular ganglion, c — vestibular ganglion, d — geniculate ganglion and trunk of facial nerve, e — cochlear ganglion.

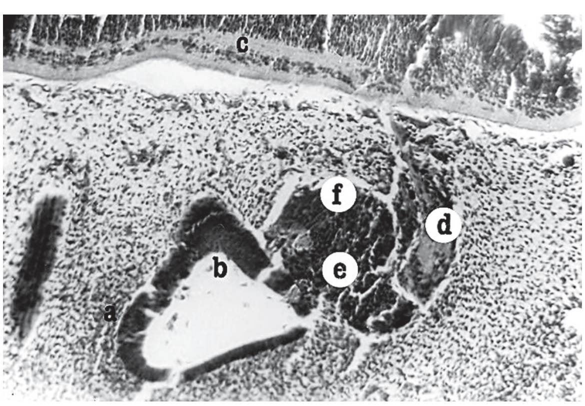

Figure 16. Sagittal section of embryo at stage 15. H + E, × 150; A — capsule of otic vesicle, b — otic vesicle, c — common afferent tract, d — geniculate ganglion, e — cochlear ganglion, f — vestibular ganglion.

In present study the geniculate ganglion was already identified in embryos at stage 13. It was also possible to identify the vestibular and cochlear ganglia within the vestibulocochlear complex. The geniculate and vestibulocochlear ganglia develop from the crest cells of rhombomere 4. This was confirmed by O'Rahilly and Müller [11–13, 15].

The origin of cells of the geniculate, cochlear, and vestibular ganglia is still definitely not established. The geniculate ganglion arises from the neural crest and somatic ectoderm. The vestibular and cochlear ganglia are formed mainly from the otic vesicle and they receive contribution from the neural crest [20, 21].

The observations of Altman and Bayer [1] suggest that all cranial nerve ganglia in the rat derive from placodes, with no contributions made to the neuronal population by the neural crest. The neural crest neurons during migration through the mesenchyme may be mixed with placode-derived neurons and may change their phenotype.

The cranial ganglia derived from neural crest show a specific relationship to individual neuromeres, and rhombomeres are better landmarks than the otic primordium, which descends during stages 9–14 [14].

In stage 13 and 14 we observed nerve cells lying between the neural tube and the vestibulocochlear ganglion. These cells represent the neural crest cells.

The contribution of cells from the otic placode in stages 13 and 14 was mentioned by Müller and O'Rahilly [9, 10, 14, 16].

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