THE PLEXUS CHORIOIDEUS IN THE ADULT GOAT: A SCANNING ELECTRON MICROSCOPE STUDY

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Abstract


The surface of plexus chorioideus of the fourth, third and lateral ventricle and in the region of the foramen interventriculare of adult goats of both sexes was studied using scanning electron microscopy. It was found that the convex apical membranes on the whole surface of the plexus chorioideus are covered with microvilli or microvillus-like structures. The presence of cilia was not recorded. Abundant spherical protrusions occurred in the region of lateral cerebral ventricle, and were almost absent in the region of the foramen interventriculare. The epiplexal cells occurred in the fourth and lateral ventricle only sporadically; they could be seen in higher number in the third ventricle and in the region the foramen interventriculare. Some epiplexal cells had a large number of filiform processes; most of these macrophage-like cells had only 3-5 pseudopodia with “ruffled” membranes. No differences which would be connected with sex or season were found in the structure of the plexus chorioideus.

Central nervous system, plexus chorioideus, cerebral ventricles, microvilli, secretory protrusions, epiplexal cells, adult goat

The plexus chorioideus (PCH) is situated in the cerebral ventricles and produces the greater part of the cerebrospinal fluid. It is a part of pial blood vessels invaginated into the ventricular space, villi formally arranged and covered with one layer of predominently cuboid epithelial cells. Their apical membranes have a characteristic structure, which is very similar to the apical membranes of ependymal cells of the cerebral ventricular system (presence of microvilli, spherical protrusions or macrophage-like cells).


The aim of the work was to study the plexus chorioideus surface in adult goats by scanning electron microscope.

Materials and Methods

Twelve adult goats of both sexes (9 females and 3 males) were used. They were killed between spring and autumn. Immediately after exsanguination, the heads of animals were perfused through a. carotis communis with 0.2 mol/l phosphate buffer solution and prefixed with Karnovsky solution. The specimens of the plexus chorioideus from the fourth, third and lateral ventricles and from the region of the foramen interventriculare were postfixed in

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3% glutaraldehyde in cacodylate buffer (temperature of all solutions was 4°C, pH 7.4) and then processed by the method of Murakami et al. (1977). After dehydration in an increasing ethanol series, the specimens were dried by the critical point method, coated with gold in vacuum and studied by the Tesla BS 340 scanning electron microscope.

Results

The plexus chorioideus ventriculi quarti forms a lot of small glomoid structures (Plate I, Fig. 1). At greater magnification it can be seen that apical membranes of individual epithelial cells are convex, covered with low dense microvilli. Among them, there are sporadic or aggregated spherical secretory protrusions of different sizes (Plate I, Fig. 2). The presence of cilia was not recorded. Occurrence of epiplexal cells is rare. They have irregular bodies with thicker processes, which, either on their periphery or as a whole, form “ruffled membranes”. The surface of cells and their processes is smooth.

The plexus chorioideus ventriculi tertii is folded to a lesser degree than that in the fourth ventricle. The convex apical membranes of epithelial cells are covered with dense, short microvilli; cilia are absent. Small spherical protrusions are only sporadic. The occurrence of epiplexal cells on this part of the plexus chorioideus surface is frequent. Their bodies are irregularly round, almost elongated with smooth surface. Some of the cells have a great number of thin, fibrous processes from which the secondary branches originate (Plate I, Fig. 3A). Other epiplexal cells have 3-5 processes which are changed to “ruffled” membranes either totally or partly (Plate I, Fig. 3B).

In the region of the foramen interventriculare (FIV), the plexus chorioideus is more folded than that in the third ventricle. The convex apical membranes of epithelial cells are covered with dense microvilli; cilia are absent in this region, too. The presence of epiplexal cells in this part of the plexus chorioideus surface is frequent. Their bodies are irregularly round, almost elongated with smooth surface. Some of the cells have a great number of thin, fibrous processes from which the secondary branches originate (Plate II, Fig. 4A). Other epiplexal cells have 3-5 processes which are changed to “ruffled” membranes either totally or partly (Plate II, Fig. 4B).

Spherical protrusions did not occur in the region FIV.

Discussion

The plexus chorioideus is generally marked by the formation of recesses with large “tufts”, of different sizes, which according to Hosoya and Fujita (1973) resemble grapes. In adult goats, the PCH is the most folded in the fourth ventricle, therefore it is very fragile. The same arrangement of the PCH ventriculi quarti has already been noted in 62-day-old goat foetuses (Rajtová 1997).

The PCH surface of adult goats is enlarged due to a convex arching of the apical membranes of epithelial cells, which according to Yamadori (1972) resemble low, round hillocks. Their presence also in goats has a characteristic appearance.

The convex apical membranes of the PCH in the goats studied are covered with dense microvilli or thick, microvillus-like structures such as for example in dogs reported by...
Allen (1975), in rats by Yamadori (1972) and Chamberlain (1974). Masuzawa and Sato (1983) divided microvilli on the PCH into 1) symmetrically digitated and 2) short, round, almost club-like ones. The presence of cilia on the PCH surface in the goats studied was not recorded. Moreover, in goat foetuses (Rajtová 1997) there were short cilia arranged in clusters on the tops of the PCH apical membranes of the lateral and fourth ventricle. The presence of cilia in rats was not reported by Peters (1974) either. Their occasional presence on the PCH has been recorded by some authors in prenatal rather than postnatal period (Tennyson and Pappas 1968; Santolaya and Rodríguez Echandía 1968; Scott et al. 1972, 1974; Chamberlain 1973; Coates 1977; Persky 1980; Otani and Tanaka 1988; Rajtová 1997), which is in agreement with our findings.

Spherical protrusions of various sizes were a part of the PCH surface in adult goats. Their abundance was recorded in the ventriculus lateralis, sporadically in the third and fourth ventricle; they were absent in the foramen interventriculare region. Unlike adult goats, in goat foetuses the occurrence of spherical protrusions was abundant in the fourth, but sporadic in the third and lateral ventricles. The spherical protrusions on the PCH surface have been recorded by more authors (e.g. Santolaya and Rodríguez Echandía 1968; Clementi and Marini 1972; Peters 1974; Scott et al. 1974; Allen 1975; Coates 1977; Rajtová 1997) and all the authors consider them as a manifestation of the secretory activity of PCH.

The presence of epiplacal cells has been recorded on the PCH surface both in goat foetuses and in adult goats (Rajtová 1997). Their occurrence in the region of the fourth and lateral cerebral ventricles was only sporadic. They occurred in a greater number on the PCH surface of the third ventricle, while in the region of the FIV they were abundant.

The presence of epiplacal cells as well as supraependymal cells in the ventricular system of the brain in foetuses or in the postnatal period of some species of mammals has been reported by more authors (Scott et al. 1972, 1974; Kitamura 1972; Hosoya and Fujita 1974; Chamberlain 1974; Bleier et al. 1975; Allen 1975; Mestres and Breipohl 1976; Coates 1977; Ling 1983; Otani and Tanaka 1988). The outer morphology of these macrophage-like cells is polymorphous; this follows from the study of the above-mentioned authors as well as from our results and not only in sheep and goat foetuses (Rajtová 1997) but also in the adult goats studied. Clementi and Marini (1972) in the cat, Hosoya and Fujita (1973) in the rat or Allen (1975) in the dog described two types of epiplacal cells: those with fibrous processes and those with pseudopodia. These data correspond to those in adult goats where EPC with pseudopodia prevailed. The authors, dealing with EPC description, have not mentioned the manner of their distribution on the PCH surface: in adult goats we recorded their greatest abundance in the foramen interventriculare region, where spherical protrusions were absent. Based upon the outer morphology of these macrophage-like cells in adult goats we can suppose that EPC with fibrous processes will represent the “rest” stage, and cells with pseudopodia, which are partially or entirely changed to “ruffled” membranes, the “migrating” stage (Hosoya and Fujita 1973; Allen 1975; Coates 1977).

Most of the authors, studying EPC, concur in considering them to macrophages (Kitamura 1973; Hosoya and Fujita 1973; Chamberlain 1974; Bleier et al. 1975; Sturrock 1978, 1988; Maxwell and McGadey 1988). According to Maxwell and McGadey (1988) the EPC are more active than, for example supraependymal cells, which is especially pronounced in brain impairment. Mestres and Breipohl (1976) or Sturrock (1988) consider these cells as glial cells capable of movement not only on the ependymal surface but also on the PCH. Other authors reported on their haematogenic origin (Carpenter et al. 1970; Kitamura 1973; Ling 1983; Boya et al. 1986; Maxwell and McGadey 1988). Bienzle et al. (1995) have described the haematopoietic activity in the
PCH of the fourth ventricle of adult dogs possibly following the impairment of blood vessels.

We have not made a statement about the origin of the epiplexal cells we described in adult goats due to the fact that our study was performed only by the scanning electron microscope. No differences, related to sex, oestrous cycle of females, or resting period of males, were recorded in the structure of the PCH surface in adult individuals as had been the case with ependymal lining (Rajtová 1990).

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Fig. 1. The *plexus chorioides* surface from the region of the fourth cerebral ventricle with abundant, secretory protrusions of different sizes. Bar = 20 µm.

Fig. 2. The *plexus chorioides ventriculi quarti* surface. The convex apical membranes are covered with dense, *microvillus-like* structures. Secretory protrusions protrude through the slit between recesses. Bar = 5 µm.

Fig. 3. A, B. Details of the *plexus chorioides ventriculi tertii* surface with epiplexal cells. A: EPC with many filiform processes. One of them is changed to “ruffled” membrane (arrow). B: EPC with pseudopodia which are entirely or partially changed to “ruffled” membranes. The surface of convex apical membranes is covered with thick, *microvillus-like* structures A: Bar = 5. µm, B: Bar = 5 µm.
Fig. 4. A, B. The plexus chorioideus surface from the foramen interventriculare region. The convex apical membranes are covered with dense microvilli. A: EPC with pseudopodia are abundant, they get to the surface through intercellular spaces. Bar = 10 µm. B: Detail from the same region. One of the intercellular spaces covers EPC, the other is loose. Bar = 5 µm.
Plate III

Fig. 5. A, B. The *plexus chorioideus ventriculi lateralis* surface is covered with *microvilli* and microvillus-like thick structures. Secretory protrusions are abundant. A: Bar = 20 µm, B: Bar = 5 µm.