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Differentiation of the cortical plate in early human foetuses

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The aim of the study is to describe the differentiation of the cortical plate in human foetuses aged 9–11 weeks. Histological sections showed that in this early period of development the cortical plate is differentiated into two zones. The external zone is composed of vertical columns of cells, which are perpendicular to the cortical surface. The internal zone is wider and consists of irregularly arranged clusters of cells.

key words: human neuroembryology, foetal period, cortical plate, lamination

INTRODUCTION

The prenatal development of the cerebral cortex is characterised by transient patterns of regional, laminar, molecular and neuronal organisation [3, 4]. In the development of the cerebral cortex, an early germinal zone, the ventricular zone, gives rise, through successive rounds of cell division and migration, to the postmitotic neurones that comprise the adult cortical layers [1]. Cortical neurones with their intrinsic connections, their output projections and their afferent inputs are organised in two dimensions, one is parallel to the pial surface (the layers), the other is perpendicular to it (the columns). Cortical layers are generated in an inside-out fashion, with cells destined for the deepest layer born progressively later [11]. From available literature it is known that the formation of the neocortical layers takes place in the second half of the intrauterine development. Marin-Padilla [6] stated that in a 5-month-old human foetus "(...) there are no appreciable horizontal laminations of the cortical grey matter".

The aim of the paper is to present the formation of layers in the cortical plate in early human foetuses.

MATERIAL AND METHODS

Investigations were performed on 11 human foetuses aged 9, 10 and 11 weeks (Table I). Foetuses were from medically indicated or spontaneous abortions. Inclusion criteria were absence of cerebral malformations, developmental abnormalities and hypoxic-ischaemic changes. The procedures had the approval of the University Ethical Committee. Foetuses were embedded in toto in paraplast and serial sections were made in sagittal, horizontal and frontal planes. Sections 5 micrometres thick were stained with haematoxylin and eosin, according to the Mallory method and were impregnated with silver nitrate.

RESULTS

In foetuses aged 9 weeks the cortical plate is present on the surface of the entire neopallium and it is thickest in the region of the future insula. It consists of 8 to 12 rows of cells (Fig. 1). Under the surface of the pia mater is the marginal zone containing Cajal-Retzius cells and stellate cells. The subplate is twice the thickness of the cortical plate and is composed of loosely packed cells. The subplate is separated from the subventricular zone through the wide

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Table 1. C-R length and age of investigated foetuses

Catalogue number	C-R length in mm	Age in weeks	Plane of section
A 11	43.0	9	Horizontal
A 71	43.5	9	Horizontal
KUB 2	43.5	9	Sagittal
KR	45.0	9	Horizontal
A 2	47.5	9	Horizontal
PJK 30	48.0	9	Sagittal
B 11	48.0	9	Frontal
B 77	53.0	10	Horizontal
A	55.0	10	Sagittal
P 104	72.0	11	Sagittal
KR1	78.0	11	Frontal

intermediate zone in which there are irregular bands of cells and many blood vessels. The subventricular and ventricular zones are not clearly demarcated and the ventricular zone is thicker.

Substantial changes in the structure of the neopallium are observed in foetuses of 10 and 11 weeks. The cortical plate, which may be considered as the primary cortical grey, differentiates into 2 zones (Fig. 2). The plate is thickest on the dorsolateral surface of the hemisphere. The external, narrow zone contains vertical columns of cells (Fig. 3, 4), which are perpendicular to the cortical surface. The wider internal zone consists of irregular groups of cells with oval and pyramidal neurones. Blood vessels are present in both zones (Fig. 4).

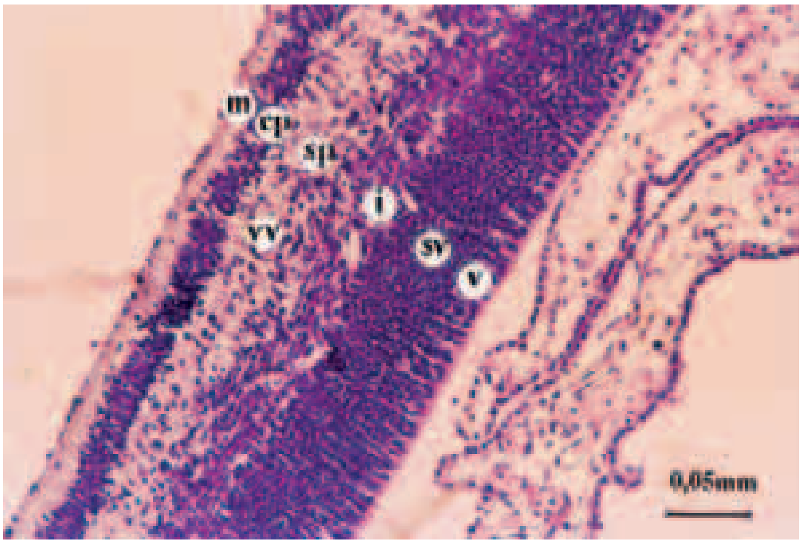

Figure 1. Horizontal section of hemispheric wall in foetus aged 9 weeks; cp — cortical plate, i — intermediate layer, m — marginal layer, sp — subplate, sv — subventricular layer, v — ventricular layer, vv — blood vessels.

Figure 2. Horizontal section of hemispheric wall in foetus aged 11 weeks; cp — cortical plate, cpe — external zone of cortical plate, cpi — internal zone of cortical plate, i — intermediate layer, m — marginal layer, sp — subplate, sv — subventricular layer, v — ventricular layer, vv — blood vessels.

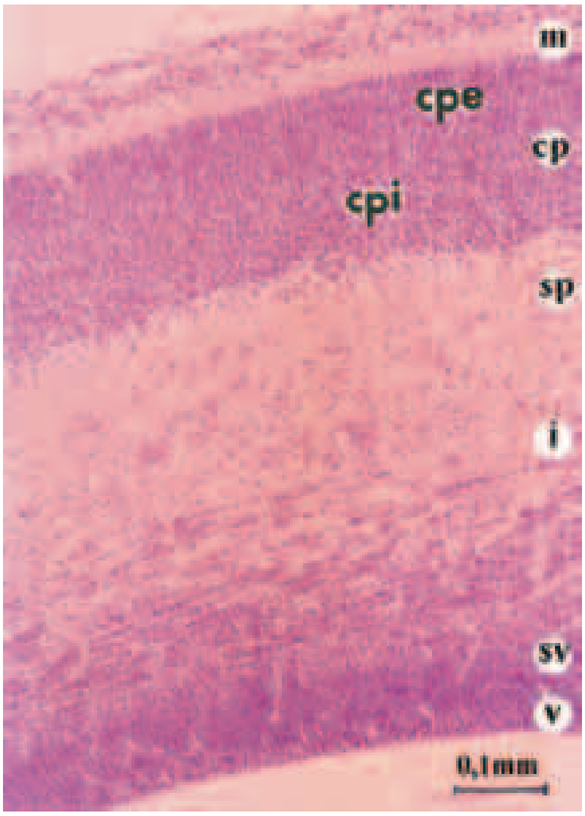

Figure 3. Horizontal section of hemispheric wall in foetus aged 11 weeks; cp — cortical plate, cpe — external zone of cortical plate, cpi — internal zone of cortical plate, i — intermediate layer, m — marginal layer, sp — subplate, sv — subventricular layer, v — ventricular layer.

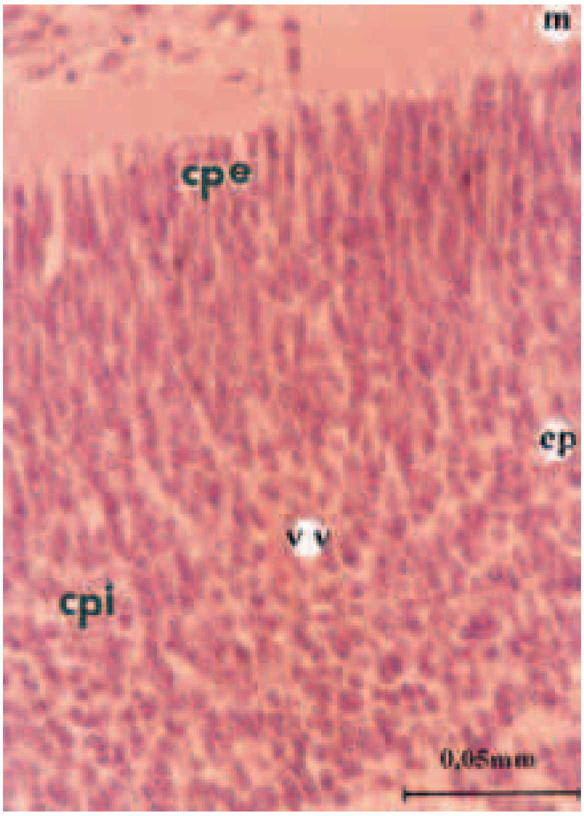

Figure 4. Cortical plate and marginal layer in foetus aged 11 weeks; cp — cortical plate, cpe — external zone of cortical

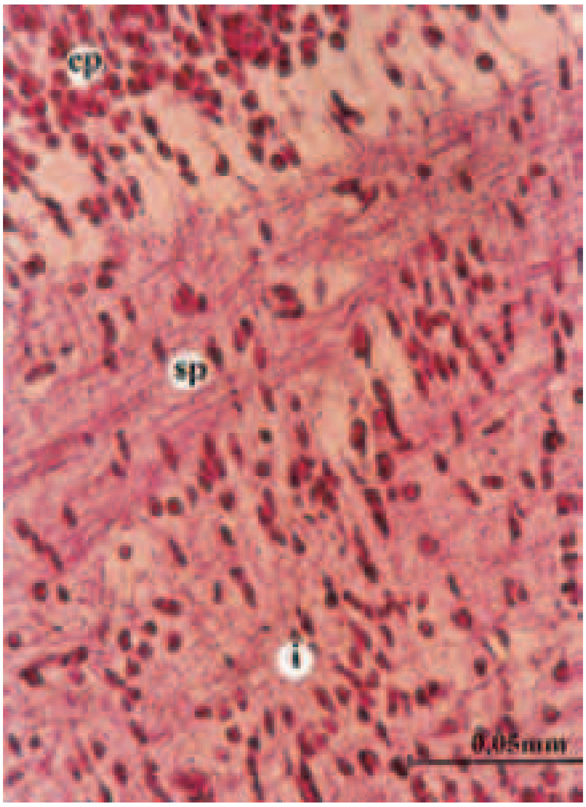

Figure 5. Subplate and intermediate layer in foetus aged 11 weeks; cp — cortical plate, i — intermediate layer, sp — subplate.

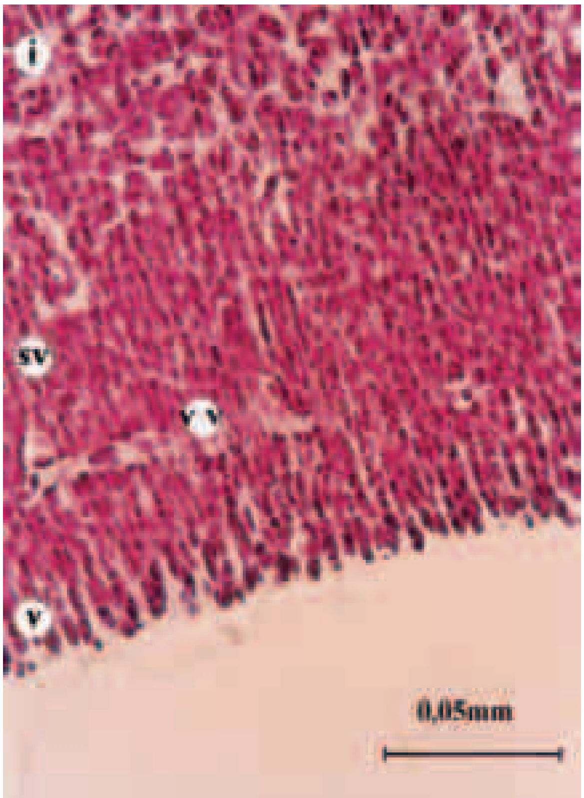

Figure 6. Subventricular and ventricular layers in foetus aged 11 weeks; i — intermediate layer, sv — subventricular layer, v — ventricular layer, vv — blood vessels.

The narrow subplate is formed of loosely packed cells and transversely arranged fibres (Fig. 5). The widest is the intermediate zone. It is composed of a larger external layer (Fig. 5) and a thin internal layer (Fig. 6) containing groups of cells. The subventricular zone is much thicker than the ventricular one. Both zones contain blood vessels.

DISCUSSION

According to the terminology of the Boulder Committee the wall of the developing telencephalon consists of four zones, called, from the ventricle outwards, the ventricular, subventricular, intermediate and marginal zones [2]. Cells proliferate in the ventricular zone during early stages and in the subventricular zone at later stages of development [5, 12]. The marginal zone consists of tangential fibres and the first neurones to be generated, and becomes layer I of the cortex. This nomenclature was modified and updated by Allendorfer and Shatz [1]. They propose the following diagram during neocortical development: initially, the cerebral wall comprises a germinal zone, the ventricular zone and a marginal zone. As the first postmitotic cells migrate from the ventricular zone, they settle below the marginal zone to form the preplate, or primordial plexiform layer. With ensuing neurogenesis and migration, a cell-dense zone, the cortical plate, forms. Preplate neurones are split into two populations that comprise the marginal zone and the subplate.

The most fundamental change in the embryonic differentiation of the wall of human cerebral hemisphere is the appearance of the cortical plate at stage 21 [8]. It first appears in the region of the insula, and consists of 3–5 rows of cells. At the end of the embryonic period the cortical plate reaches over the main neocortical surface. The plate furnishes either layers 2–6 [7] or layers 2–5 [9], and layer 6 derives from the subplate [5].

A detailed histological and histochemical analysis of the developing human brain is necessary for a proper interpretation of the neurobiological basis of the rapid changes in prematurely born infants [10, 13].

Our results showed that the lamination of the cortical plate occurs early in the foetal period. In foetuses aged 10 and 11 weeks the cortical plate differentiates into external and internal zones. This may be considered as the development of the cortical layers.

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