DEVELOPMENT OF NONSPECIFIC THALAMIC NUCLEI DERIVED FROM THE DORSAL THALAMUS IN RABBITS

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The nonspecific nuclei, which are derivatives of the thalamus proper, are characterized by high rates of architectonic and cytological differentiation. The parafascicular complex develops particularly early.

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In a previous investigation [1] we examined the development of nonspecific nuclei derived from the ventral thalamus, i.e., the reticular nucleus and the nucleus reuniens. Many more of the nonspecific nuclei differentiate from the dorsal thalamus, i.e., they are derivatives of the true thalamus. The present investigation was carried out to study the development of these nuclei.

The parafascicular complex includes the parafascicular nucleus (n. parafascicularis, Pf), surrounding Maynert's tract, the subparafascicular nucleus (n. subparafascicularis, Spf), lying ventrally to the first nucleus, and the centrum medianum (CM), the most lateral spur of the complex, highly developed only in primates.

The parafascicular complex obtained fibers from the reticular formation of the rhombencephalon and mesencephalon [7, 9, 11]. A projection of visceral afferent fibers in the parafascicular complex has been found [2]; connections with the cortex are indirect, via the reticular nucleus and subcortex.

In recent investigations responses of the CM to nociceptive stimulation have been recorded [5, 8, 10]. However, morphological and physiological data obtained by other workers [12, 13] suggest that the CM is only associated with pain integration to the extent that it relays fibers on their way to the intralaminar nuclei. Descending pathways have been found from the parafascicular complex to the reticular formation of the rhombencephalon and mesencephalon.

The experimental method was described previously [1].

EXPERIMENTAL RESULTS

According to our observations the parafascicular complex begins to differentiate architectonically in the 20-day rabbit fetus (Fig. 1).

From the time of formation of the parafascicular complex, when examined under immersion it could be seen to contain separate, thin fibrils. They were clearly outlined and distinguishable from the diffuse glio-cytoplasmic anlage of Maynert's tract passing through the parafascicular complex. The fibers were radial in direction. I consider that these fibrils are nonspecific afferents running from the earliest developing cells of the bulbar reticular formation, which itself develops sooner than the nuclei give rise to specific fibers [6].

On the 22nd day of embryonic life the cells of the caudal division of the parafascicular complex enter the transitional period toward ...e neuron (primary tigroid and a few neurofibrils appear). At 25 days all the cells of the parafascicu... complex are in the stage of transition from neuroblasts to neurons. On the 27th day the tigroid granul... how lysis. The cytoplasm acquires a well-marked foamy basophilia. The nucleus is also darkly sta...d; the chromatin granules, which in the preceding stages were apparently compressed against the n...ear membrane, disappear or diminish greatly in size.

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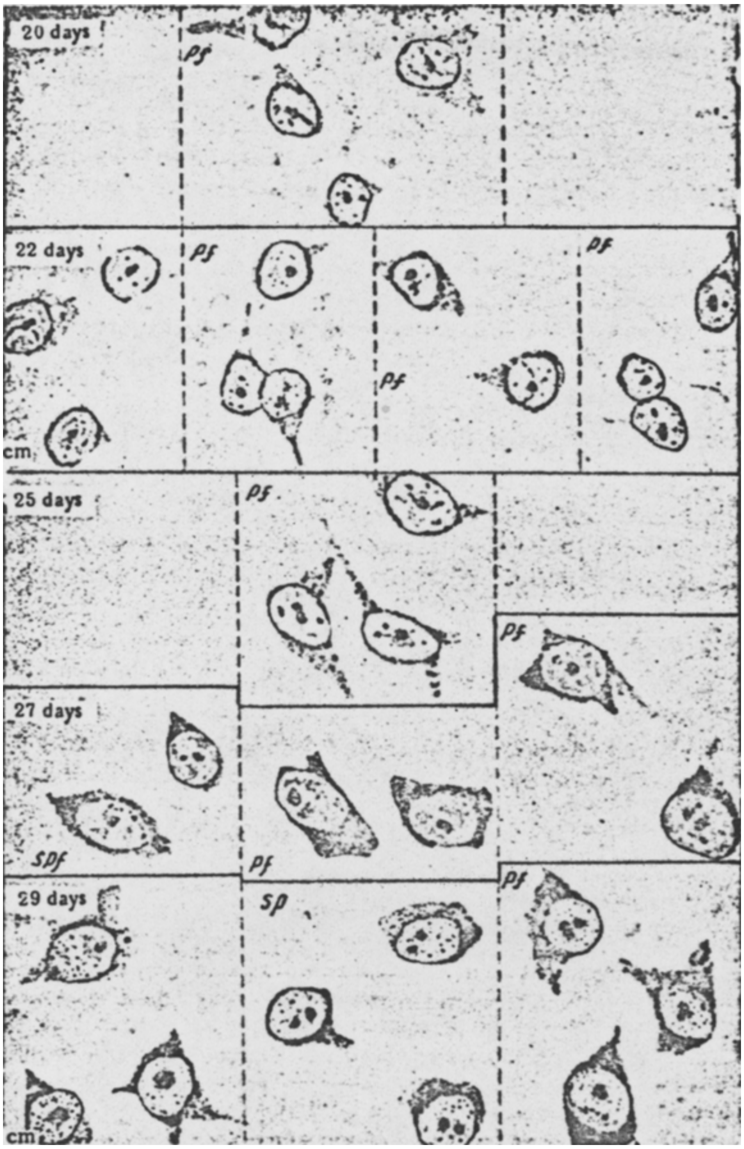

Fig. 1. Development of cells of the parafascicular complex of the rabbit thalamus. Nissl's method. Cells drawn by means of an Abbe apparatus under magnification 40 × 20.

In preparations stained by the Golgi method the cells of the parafascicular complex are distinguished by possessing few branches, as is characteristic [3, 4] of reticular formations. The number of dendrites varies from 5 to 7. Bifurcation of the dendrites is either absent or observed on one dendrite. The dendrites and axon are long, but in the prenatal period they do not extend beyond the nucleus. The axon varies in direction: strictly dorsally, strictly ventrally, or ventrolaterally. Varicosities are frequently observed on the dendrites and axon.

In preparations from 27-day embryos, impregnated with silver, still very few single nerve fibrils could be seen in the glio-cytoplasmic bands. In addition, single very fine mature fibrils were observed. As mentioned above, in Golgi preparations thin nerve fibrils were discovered from the moment of architectonic differentiation of the nucleus, i.e., from the 20th day of embryonic life.

Neurons of the parafascicular complex attain the stage of maturity at the same time as neurons of other thalamic nuclei, by the 2nd-5th day of postnatal life.

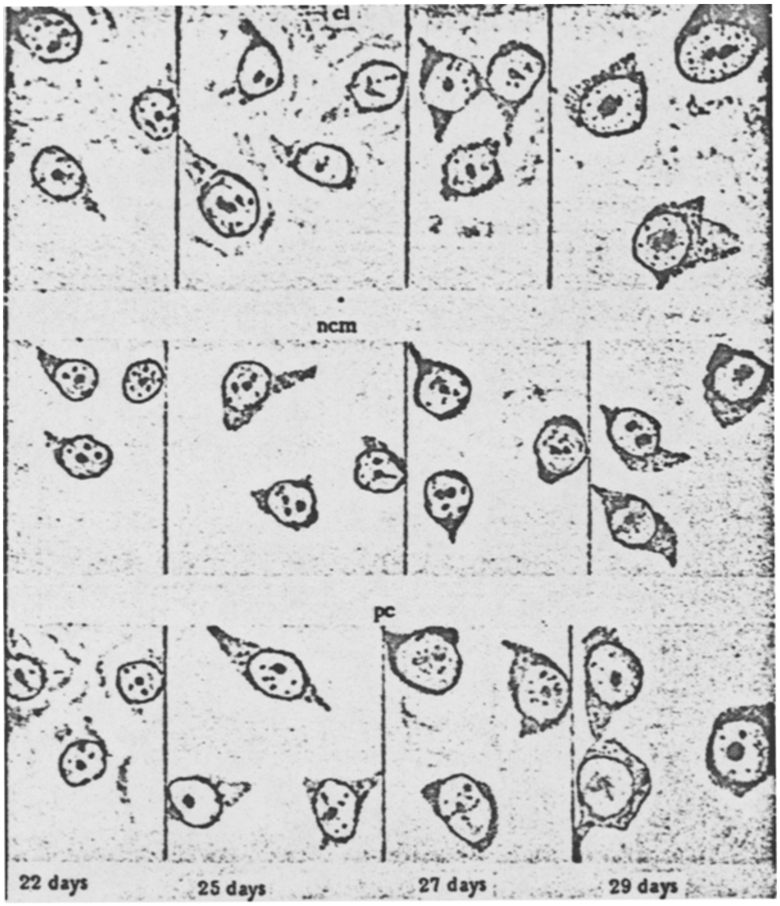

Fig. 2. Development of n. centralis lateralis (cl), n. centralis medialis (ncm), and n. paracentralis (pc) of the rabbit thalamus. Legend as in Fig. 1.

The nucleus paracentralis and nucleus centralis lateralis (cl) appear from the time of primary architectonic differentiation of the thalamus, at the stage of the 22nd-day embryo.

Situated in the anterior part of the internal medullary lamina, these nuclei possess extensive connections with the parafascicular complex through the intrathalamic bundle of fibers, with the lateral and medial thalamic nuclei, and with the reticular nucleus, subcortex, and cortex. The intralaminar nuclei receive fibers of the paleospinothalamic system – the medial division of the spinothalamic system.

Numerous fibers approach the intralaminar nuclei in the reticular tracts of the trigeminal nerve system. In a recent investigation, Steward and King [12] found that fibers from the caudal part of the spinal nucleus of the trigeminal nerve run in the bulbar reticular formation and are directed particularly toward the nucleus centralis medialis and nucleus centralis lateralis. These workers consider that the tract from the caudal nucleus of the trigeminal nerve to the intralaminar nuclei of the thalamus conducts nociceptive impulses and that the intralaminar nuclei of the thalamus constitute the thalamic relay of pain sensation.

The internal medullary lamina, in which the anterior intralaminar nuclei lie, at the 22nd-day stage contains numerous glio-cytoplasmic bands (mainly directed transversely in frontal section), numerous nerve fibrils arranged in short radial bundles, and separate radial nerve fibrils. The system represented by mature fibers is evidently formed by axons of the reticular cells of the pons and medulla, forming the nonspecific part of the trigeminal loop and the spinothalamic system.

The anterior intralaminar nuclei are connected with the cortex mainly via the inferior thalamic peduncle, and to a lesser degree via the lateral thalamic peduncle.

At the age of 25 days cells of both nuclei begin to change from neuroblasts to neurons (Fig. 2).

Intralaminar cells located directly beneath the anterior part of the nucleus lateralis are very similar in character and rate of development to the cells of other nonspecific structures just described: the nucleus centralis medialis and nucleus ventralis anterior.

The results described above indicate the early appearance and early differentiation of structures of the thalamic reticular system. Of the specific nuclei, only the n. centralis posterior possesses such a high rate of development. However, the nonspecific nuclei vary as regards both hodology and ontogenesis.

The parafascicular complex is the first of the thalamic nuclei to enter the critical period of transition from neuroblast to neuron. By the 22nd day of embryonic life tigroid granules can be seen in the cells of its caudal portion. It must be emphasized that development of the medial part of the n. ventralis posterior is only 1-2 days behind that of the parafascicular complex. All the other specific and nonspecific nuclei of the thalamus enter the period of transition to neuron somewhat later.

Connections of the parafascicular complex have already been mentioned above. I consider that the early development of this structure is certainly associated with the early development of afferent connections from the reticular formations of lower levels of the brain stem.

The anterior intralaminar nuclei (n. paracentralis, n. centralis lateralis, and the cell structure connecting them, the nucleus centralis medialis) obtain afferent connections from the reticular structures of the trigeminal nerve system (along the dorsal trigeminal-lateral reticulothalamic tract), the paleothalamic system and, in particular, from the amygdala. Hodological and physiological experiments can differentiate the group of anterior intralaminar nuclei. For instance, the amygdala is connected with the n. paracentralis, while the n. centralis medialis and n. centralis lateralis are connected mainly with the system of the trigeminal nerve.

No clear differences were found as regards the type of structure of the nerve cells, the time when they enter the period of transition to neuron, and the rate of differentiation between the anterior intralaminar nuclei.

The anterior part of the n. lateralis, which also commences cytological differentiation on the 25th day of embryonic life, is intimately connected with the intralaminar nuclei.

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