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CONTRIBUTION TO THE ANGIO-ARCHITECTURE OF THE HYPOTHALAMUS

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In the present paper we wish to report on examinations concerning the blood-supply of various hypothalamic areas, with special regard to the differences between their angio-architecture.

Recent functional and pathological examinations have revealed the great importance of the hypothalamus ; our extended knowledge regarding the part played by the hypothalamicohypophyseal system lends particular interest to investigations into the circulatory arrangement of the hypothalamus. The question of neuronal secretion, the so-called neurocriny, of some hypothalamic cell groups is still under discussion, the most recent view being that the secretions of the neurocrine cells escape partly through the lymphatic spaces, and partly through the capillaries surrounding the cells *(R. Collin)*. This, of course, lends special significance to the vascular supply of the so-called neurocrine nuclei.

On the strength of the principle that the intensity of vascularisation is in direct proportion to function, a comparison of the vascular structure of one hypothalamic region of known function with that of another such region, as well as a comparison of the cyto-architecture with the angio-architecture of each region, is bound to yield valuable data for the practice.

As haemorrhages occurring in the hypothalamic areas exert a far-reaching effect on the organism, investigation into the vascular structure of the different regions of the hypothalamus seems to be calling also for a pathological interest.

The examinations under review are chiefly concerned with the microtopography of the hypothalamic vessels.

The hypothalamus of three dogs and three humans, all injected with India-ink, further the hypothalamus of humans injected with x-ray contrast material, have been subjected to examination.

As regards the hypothalamus of dogs, it should be noted that, according to *Roussy* and *Mosinger* who made comparative studies of the human and canine hypothalamus, there exists a striking analogy between these two kinds of hypothalamus : the analogy goes so far as to admit of a parallel being drawn between hypothalamic lesions induced in dogs and those occurring pathologically in

humans. The terminology employed in this paper to denote the various areas and/or portions of the hypothalamus, has been borrowed from the said authors.

In order to examine the vascular tree of the hypothalamus, it has been found convenient to follow the division of the hypothalamus into pars chiasmatica, pars tuberalis and pars mamillaris, to subject the vascular supply of these regions separately to examination, and to compare their vascular arrangements with one another.

It is known from the investigations of *Heubner* and *Duret* (cit. sec. *Mihalkovics)* regarding the vessels of the human hypothalamus that the vascular bed at the base of the brain sends arteries to the hypothalamus ; this bed is made up of the anterior cerebral artery, the anterior and posterior communicating arteries, and the antero- and postero-medial thalamic arteries : the latter had been held by older descriptions to arise mostly from the posterior cerebral artery, whereas, as revealed by the investigations of one of the present authors, they mostly take their origin from the posterior communicating artery. The veins of the hypothalamus empty into the great vein of Galen, according to *Mihalkovics*, through Rosenthal's basal vein. Arising in the neighbourhood of the anterior perforated substance, and draining the chiasma, optic tract, tuber cinereum and the mamillary body, this vein curves round the cerebral peduncle, to empty, in the transversal cerebral fissure, into the terminal part of the great vein of Galen, or, else, into the straight sinus.

X-ray examinations of the human hypothalamus after filling with minium suspended in terpentine, revealed that the hypothalamus is penetrated by a great number of perpendicular arteries coming from the posterior communicating artery and, in a lesser number, from the posterior cerebral artery ; part of them ramify in this area of the brain, while a part of the perpendicular arteries travel on to the thalamus (Fig. 1). Following *Pfeiffer*'s classification, these arteries may be regarded as »Dolcharterien« (»dagger-arteries«) the like of which are encountered in the case of the striate arteries and in the cerebral cortex. The many perpendicular arteries in question can be well observed in thick sections made from India-ink-injected preparations.

Microscopical studies have yielded the following results.

(i) *Chiasmatic region*

Compared to its surroundings, the vascular supply of the chiasma is poor. It contains chiefly capillaries, with a very limited number of larger vessels. The poor vascularization of this region corresponds to the general vascular arrangement of the white matter (Fig. 2).

The praechiasmatic part of the supraoptic nucleus is much more abundantly vascularized. Numerous perpendicular arterial trunks penetrate into

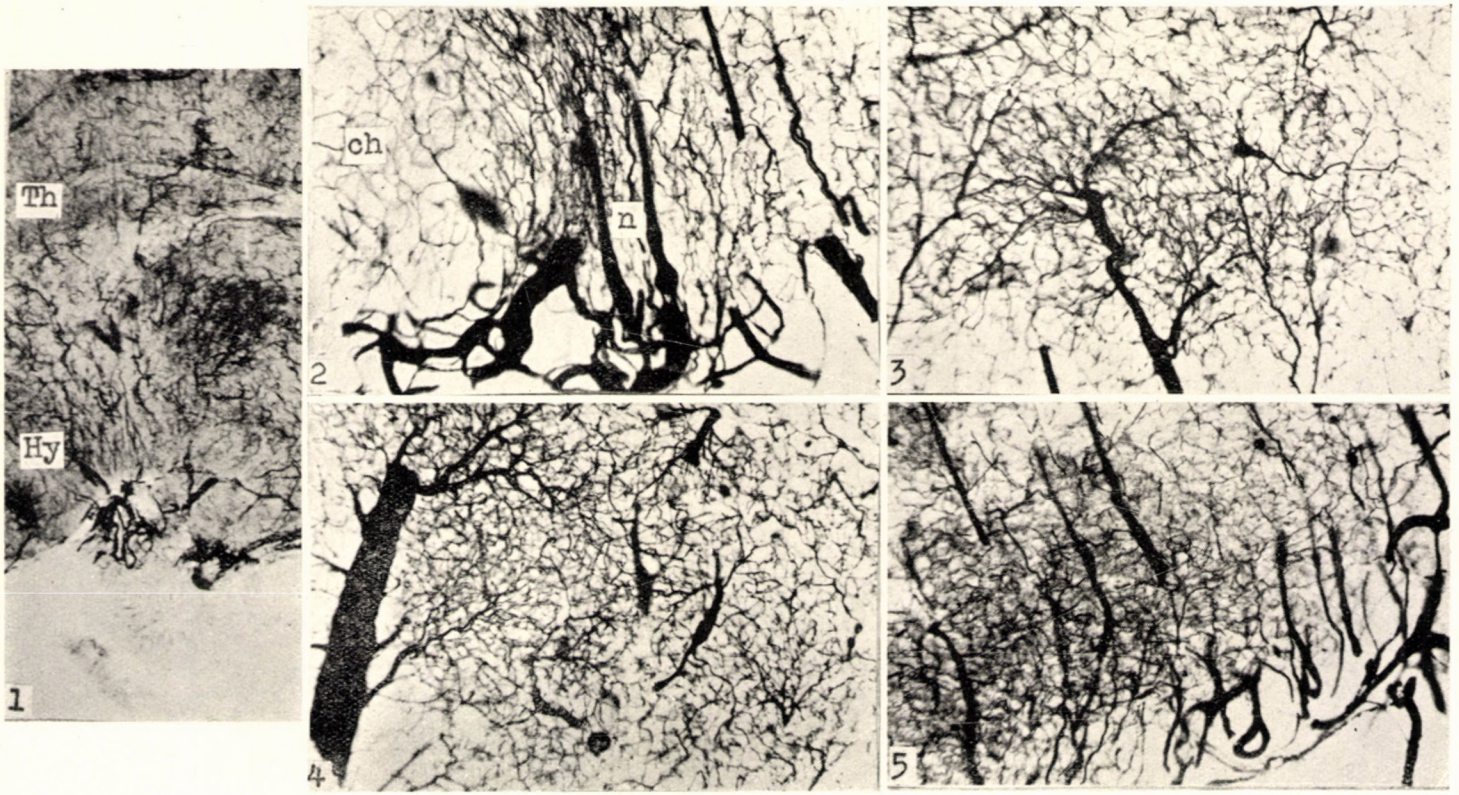

Fig. 1. Man. Vessels of hypothalamus and thalamus. Injection with X-ray contrast material Radiograph; natural size.
Fig. 2. Dog. Vascular pattern of supraoptic nucleus. Injection with India-ink. 40× ch.: chiasma, n.: supraoptic nucleus.
Fig. 3. Dog. Paraventricular nucleus. Circumscribed, rich capillary bed. Injection with India-ink. 25×.
Fig. 4. Dog. Sinusoidal veins in the paraventricular nucleus. Injection with India-ink. ×40.
Fig. 5. Dog. Angio-architecture of mamillary body. Injection with India-ink. 40×.

this part of the nucleus, part of them to pass on to the surroundings, while the rest to divide among the cells.

The retrochiasmatic part, forming a crescent around the postero-superior part of the perpendicular ones that, originating in the antero-medial thalamic artery, enter the hypothalamus. Here, too, part of them runs through the nucleus, while another part supplies the nucleus itself. Observations have proved that although both the supraoptic and paraventricular nuclei possess an equally rich capillary bed, the vascular architecture of these nuclei is different ; while in the supraoptic nucleus perpendicular vessels dominate (Fig. 2), the paraventricular nucleus has a vascular pattern suggestive of the branching of a tree (Fig. 3). Both the supraoptic and the paraventricular nucleus are richly supplied with wide sinusoidal capillaries.

The paraventricular nucleus of the hypothalamus is situated obliquely up and backward from the chiasma. Its median, the so-called principal part, consisting of numerous uni-, bi- and tripolar great cells and a restricted number of small cells, is sharply outlined *(Roussy* and *Mosinger)*. The great vascular density of this nucleus, as compared to the vascularization of the surrounding parts, is conspicuous. The richness of the capillary bed corresponds to the abundance of cells in this area, and is composed almost exclusively of capillaries, with complete exclusion of greater perpendicular arteries. This distinguishes its vascular pattern from that of the supraoptic nucleus (Fig. 3). In the paraventricular nucleus fairly wide veins and sinusoidal capillaries are present (Fig. 4).

(ii) *Tuberal region*

Nuclei, as clearly circumscribed as those in the chiasmatic region, are not encountered in the tuberal region. Cytologically, the cells are multipolar, of variable size, and generally smaller than those of the supraoptic and the paraventricular nuclei *(Roussy* and *Mosinger)*. The vascular structure of this area corresponds to this topographical arrangement and this type of cyto-architecture.

The region in question is rather thinly vascularized, and, apart from the perpendicular vessels running through the basal part, no vascular bed with any peculiar characteristics can be distinguished.

(iii) *Mamillary region*

The mamillary region is undoubtedly the most abundantly vascularized area of the hypothalamus. According to *Roussy* and *Mosinger*, it contains eight nuclei, viz. the internal and external mamillary nucleus, the premamillary,

supramamillary, hypothalamo-mamillary nuclei, the paraventricular gray matter, the fundamental gray matter, and the hypothalamic segment of the reticular nucleus. The cells are multipolar, densely packed, and there is no clear borderline between areas of large and small cells.

With the exception of the above mentioned particular cell groups in the chiasmatic part, this region represents the most richly supplied vascular portion of the hypothalamus. A great number of veins can be seen in this portion as compared to the other hypothalamic areas. The fact that haemorrhages are comparatively frequent in this region may be attributed to its great vascular density. The vascular supply of the premamillary nuclei and of the paraventricular gray matter, the latter extending from the lower part of the mamillary body to, and entering the tuberal region, shows the same density as the mamillary body (Fig. 5).

General angio-architecture of the hypothalamus

It has been found that, as regards vascular arrangement and vascular density, two separate hypothalamic regions may be distinguished.

One of these vascular regions coincides with the ventral part of the hypothalamus (hypothalamus anterior), and is, corresponding to the particular nuclei, richly vascularized in some areas. The vascular arrangement of the anterior hypothalamus is in keeping with its reticular structure, the latter being made up of nerve cells planted among nerve-fibres. This region includes two richly vascularized parts, those corresponding to the supraoptic and the paraventricular nuclei.

The other of the said vascular regions coincides with the posterior hypothalamus, the mamillary region. This is the most abundantly vascularized portion of the hypothalamus, where no such variations occur between medullary and nuclear vascularization, as have been observed in the anterior hypothalamus.

Conclusions

Confirming *Finley*'s description, certain correlations between the recently studied neurocrine areas of the hypothalamus and their vascularization have been demonstrated to exist. The two neurocrine nuclei in the anterior hypothalamus i. e. the supraoptic nucleus and the paraventricular nucleus, possess a rich capillary bed standing out of the surroundings. This capillary bed contains, especially in the paraventricular nucleus, a great number of veins, similar to the ampullary veins of the basal ganglia. The vascularization of these two nuclei may be said to represent the most abundant blood supply to be found anywhere

in the hypothalamus. Possessing sinusoidal capillaries, these neurocrine nuclei of the hypothalamus have a special vascular pattern, and it appears that the neuro-secretion woud have been connected not only with an increase in the number of capillaries but also with changes in their shape and lumen, or, in other words, with their particular morphological appearance.

It was further found that, as a rule, vessels and nerve-fibres run a parallel course in thinly vascularized medullary areas. This is clearly shown in Fig. 2, where a sharp transition is observable between the vascular pattern of the transversal fibres of the chiasma and the perpendicular ones of the hypothalamus. An entirely similar picture is presented by the vascular structure of the anterior commissure in the anterior hypothalamus.

As regards angio-architecture, the vascular arrangement of the hypothalamus occupies the middle place between medullary areas and gray matter (cerebral cortex, basal ganglia). The hypothalamus can be said to have a reticular vascular supply, the functionally significant, more abundantly vascularized portions standing out of the reticulated vascular bed.

Summary

1. The anterior part of the hypothalamus, including the chiasmatic and tuberal parts, is less uniformly vascularized than the posterior part which includes the mamillary areas. The supraoptic and paraventricular nuclei, with their abundant vascular supply, are conspicuous within the anterior hypothalamic area.

2. A relationship between the cyto-, myelo- and angio-architecture of the different hypothalamic regions has been found to exist.

3. The angio-architecture of the hypothalamus is of the reticular type, constituting a transitory form between the medullary and the nuclear types of vascular pattern.

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О КРОВОСНАБЖЕНИИ ПОДБУГРОВОЙ ОБЛАСТИ

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Р е з ю м е

Авторы в настоящей работе сделали предметом своих исследований микротопографию сосудов подбугровой области. Исследования были проведены над подбугровыми областями людей и собак. Сосуды инъицировались отчастью рентгеновской контрастной массой, а отчастью тушью. Строение сосудов подбугровой области исследовалось отдельно в области перекреста зрительных нервов, в области серого бугра и в области сосковидного тела.

На основе своих исследований авторы установили, что по расположению сосудов, а также по густоте сосудистой сети, в подбугровой области можно различить две сосудистых области. Одна область соответствует передней части подбугровой области, включая область перекреста зрительных нервов и область серого бугра. Из этой области выделяются особой густотой сосудистой сети (nucleus supraopticus и nucleus paraventricularis). В этих ядрах, выполняющих нейрокринную функцию, сосудистая сеть имеет специальное строение, поскольку там имеются синусоидные (пазухообразные) капилляры. Другая сосудистая область соответствует задней части подбугровой области, области сосковидного тела. Капиллярная сеть тут более плотная, нет отдельных участков, выделяющихся особенно густо расположенными капиллярами, как это имеет место в передней части подбугровой области. В этой области можно наблюдать наличие многочисленных вен.

По мнению авторов, результаты их исследований доказывают, что подбугровая область, по строению сосудистой сети, занимает среднее место между сосудистой сетью белого вещества головного мозга и сетью серого вещества. Ввиду этого данную область следует рассматривать как область с рыхлой сетью капилляров, из которой выделяются единичные места, особенно богатые капиллярами.