DISTRIBUTION OF NORADRENALIN IN THE SUBCORTEX OF DOGS AT VARIOUS AGE PERIODS

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The noradrenalin concentration in subcortical brain structures of dogs rises initially during ontogenesis (it is particularly high on the 9th-12th and 20th-28th days) and then falls.

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Laboratory investigations have shown that puppies aged between 1 and 16 days exhibit immaturity of the functions of the reticular formation of the brain stem and thalamus, as shown by the absence of differences in the EEG recorded during waking, sleep, and anesthesia, and also by absence of the activation produced by adrenalin and acetylcholine and of the blocking produced by chlorpromazine and atropine typically found in adult animals [2-4, 6, 9, 10, 12, 13].

Since the activating influences of the reticular formation are associated with functions of adrenergic structures [1, 17, 18, 20], in the present investigation the content of noradrenalin (NA) in various parts of the brain stem, the medical thalamus, and the hypothalamus was studied in dogs of different ages.

EXPERIMENTAL METHOD

The NA content was determined by the absorption-colorimetric method [21] as modified by B. N. Manukhin [8]. The puppies were decapitated, and adult dogs electrocuted. The skull was quickly opened and the meninges stripped from the brain. The medical thalamus, the rostral and caudal portions of the mesencephalon, the anterior and posterior hypothalamus, and the gray matter of the medulla were investigated. Samples were taken in the cold and placed in a Petri dish kept on ice. The samples were weighed and treated by the Whitehorn–Shaw method, and then examined in the FÉK-M photoelectric colorimeter.

EXPERIMENTAL RESULTS

Altogether 240 analyses were carried out on 40 animals distributed among the following age groups: 2-5 days–5 puppies, 7-8 days–4, 9-12 days–8, 20-28 days–7, 31-60 days–10, and 6 adult dogs. The results of the determinations are given in Table 1.

The NA content in the rostral and caudal portions of the mesencephalon and the medulla of adult dogs varied from 0.17 to 0.27 μg/g tissue, while in the anterior and posterior hypothalamus it was higher. The results obtained agree almost exactly with those described by Vogt [22]. In puppies aged 2-5 days the NA content was very low. No NA was present in the medial thalamus and hypothalamus. At the age of 7-8 days NA appeared in all the investigated parts of the brain, its content rising particularly considerably in the anteriror hypothalamus, caudal portion of the mesencephalon, and medulla, where it exceeded its level in adult dogs. In puppies aged 9-12 days, when they acquired the power of vision, the NA content rose considerably and became higher than in adult dogs in all parts of the brain. Hence, in the early age period (1-16 days) three subgroups could be distinguished, differing sharply in their NA content in the brain stem, thalamus, and hypothalamus.

The NA level rose particularly sharply at the age of 20-28 days (to 0.72-1.68 μg/g) in all investigated parts of the brain. At this period the standing posture, locomotion, and functions of the telereceptors become established. Differences arise in the EEG during sleep and waking, and activation responses to adrenalin, acetylcholine, and eserine appear during the action of sensory stimuli. Inhibition of cortical rhythms

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TABLE 1. Content of Noradrenalin (in μg/g) in Thalamus, Hypothalamus, and Various Parts of Brain Stem of Dogs in Various Age Periods (M ± m)

Age (in days)	Medial thalamus	Anterior hypothalamus	Posterior hypothalamus	Mesencephalon		Medulla
				rostral portion	caudal portion	
2–6	0	0	0	0,088±0,0235	0,12±0,062	0,032±0,0196
7–8	0,185±0,145	0,627±0,151	0,05±0,173	0,155±0,0653	0,367±0,1518	0,33±0,5466
9–12	0,32±0,089	0,79±0,328	0,69±0,398	0,39±0,0615	0,41±0,1040	0,5±0,124
20–28	1,2±0,54	1,68±0,134	1,64±0,196	0,72±0,156	1,01±0,1597	1,01±0,20
31–60	0,21±0,045	0,63±0,161	0,96±0,226	0,38±0,080	0,35±0,03	0,41±0,298
Adult dogs	–	0,83±0,157	0,35±0,107	0,19±0,01	0,27±0,057	0,17±0,0619

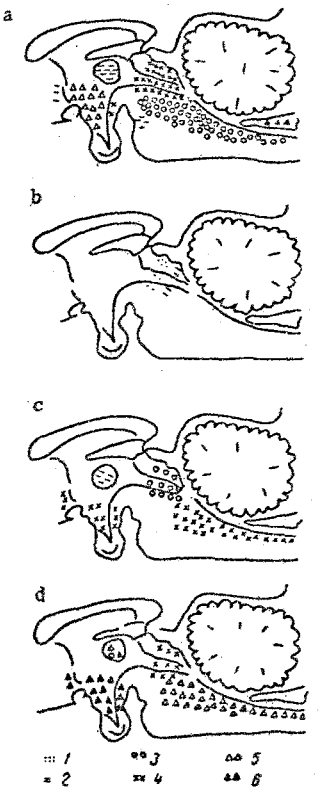

Fig. 1. Diagram of NA distribution in the medial thalamus, hypothalamus, mesencephalon, and medulla of adult dogs (a) and in puppies aged 2-5 days (b), 9-12 days (c), and 20-28 days (d). 1) Traces of NA; 2) NA content 0.2-0.3 μg/g; 3) 0.3-0.4 μg/g; 4) 0.4-1 μg/g; 5) 1-1.2 μg/g; and 6) 1.4-1.9 μg/g.

appears during natural and narcotic sleep and also during the action of drugs blocking adrenergic and cholinergic systems [2-4, 6, 10-13]. It will be noted that the NA content rose particularly sharply in the anterior and posterior hypothalamus and in the medial thalamus.

At the age of 30-60 days the NA content fell in most parts of the brain to 0.21-0.41 μg/g, and in the hypothalamus to 0.63-0.96 μg/g. As the adult stage was approached the NA level fell still lower in all parts of the brain except the anterior hypothalamus.

The pattern of distribution of NA in the subcortical brain structures of dogs of the four age groups are shown in Fig. 1, and for convenience of comparison with Vogt's findings, the data are presented in the same manner. The almost complete absence of NA in the puppies' brains in the neonatal period and elevation of its level until the 20th-28th day of life will be apparent.

DISCUSSION OF RESULTS

The low NA content in the brain of newborn puppies determined in our experiments is in agreement with results obtained by several authors investigating animals of other species [16, 19]. It is one of the causes of immaturity of the functions of the reticular formation at this age. The presence of low-frequency and low-amplitude bioelectrical activity during both waking and sleep can be explained by the absence of the "energizing" [18] action of the adrenergic structures of the reticular formation of the brain stem. However, the increase in NA content in puppies at the age of 9-12 days above its level in adult dogs is unaccompanied by significant changes in cortical electrical activity in different states except that it loses its periodicity and becomes constant in character. The EEG of animals in this subgroup retains the amplitude and frequency characteristics of the preceding age period. Despite the fact that the NA content at this period begins to exceed the adult level, in puppies aged 9-12 days no differences are present in the EEG during sleep and waking, during anesthesia, or during the action of adrenalin, acetylcholine, atropine, and chlorpromazine.

Hence, although the early age period (1-16 days) is divided into subdivisions in the sense of sharp differences in NA content, these differences are not a factor determining changes in cortical electrical activity. At the same time, it should be noted that the increase in NA content, especially in the hypothalamus and medulla of puppies, starting from the age of 6-12 days coincides with a sharp increase in the level of activity of the respiratory and cardiovascular systems, and also an increase in the level of oxygen consumption [5, 11]. According to observations made in our laboratory,

this period is marked by the maximal level of activity of these systems, and this may be associated with the particularly sharp increase in NA content in parts of the brain participating in regulation of the activity of the autonomic systems of the body.

The sharp increase in NA content in puppies at the age of 18-20 days, especially in the hypothalamus and medulla, coincides with a marked increase in their activity in the environment in connection with establishment of locomotor activity, the functions of telereceptors, and the appearance of orienting, defensive, and stress reactions [12]. I. A. Éskin and R. N. Shchedrina [15] also associate the sharp increase in NA content in rats at the age of three weeks with the appearance of stress reactions. It can be postulated that the increase in NA content in puppies aged 20-28 days is also connected with establishment of ascending activating influences. At the same time, the increase in NA content in the mesencephalon, where the reticular formation plays an important role in the establishment of these influences, is smaller.

The further development of the functions of the reticular formation at the age of 31-60 days is not connected with any increase in NA content. On the contrary, it falls considerably, especially as the adult state is approached.

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