ROLE OF THE HYPOTHALAMUS IN REGULATION OF THE HEPATIC CIRCULATION

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The hypothalamus participates in regulation of the activity of the digestive tract [4, 14] and influences the circulation in its organs [1, 10]. Changes also have been found in the bile-forming function and metabolism of the liver during hypothalamic stimulation [2, 3, 7]. It can be postulated on the basis of these facts that hypothalamic structures may also have a role in regulation of the blood flow in the liver. However, whereas the hepatic circulation, innervation of the hepatic vessels, and their self-regulation have been discussed to a certain extent in the literature [11, 13], there are virtually no data about central regulation of the circulation in the liver and the role of the hypothalamus in this process.

The aim of the present investigation was to study the effect of electrical stimulation of various hypothalamic structures on the portal and arterial blood flow in the liver.

EXPERIMENTAL METHOD

Acute experiments were conducted on 26 dogs of both sexes, weighing 8-18 kg, under pentobarbital anesthesia (35 mg/kg). Concentric bipolar electrodes 0.8 mm in diameter (diameter of tip 0.1 mm) were inserted by means of an SÉZh-2 stereotaxic apparatus into several hypothalamic structures whose coordinates were calculated from an atlas of the dog's brain [12]. The brain was stimulated by a pulsed current from an ÉSL-2 stimulator. The parameters of stimulation were: 3-10 V, 50-200 μA, 2 msec, 50 pulses/sec, 30-60 sec. At the end of the experiments the exact location of the points of stimulation was determined by histologic study of brain sections. Pressure in the carotid artery, portal vein, and posterior vena cava was recorded with an ÉMT-31 electromanometer. The volume velocity of the blood flow in the hepatic artery and portal vein was recorded by means of an RKÉ-2 electromagnetic flowmeter. All parameters were recorded on an N-115 recorder. From the pressure difference at the entry into and exit from the system of vessels and the velocity of the blood flow in them, the resistance of the territory of the hepatic artery and of the mesenteric and intrahepatic portal vessels was calculated separately. In the course of the experiment the animals were immobilized with succinylcholine (1-2 mg/kg) and artificially ventilated.

EXPERIMENTAL RESULTS

The original values of parameters of the hepatic circulation in these experiments were as follows: arterial pressure 171.2 ± 5.6 gPa, the pressure in the portal vein 10.2 ± 0.2 gPa, the pressure in the posterior vena cava 3.2 ± 0.2 gPa, and the velocity of the blood flow in the hepatic artery and portal vein 23.6 ± 1.5 and 98.6 ± 2.7 ml/min/100 g liver respectively.

Stimulation of the various hypothalamic structures caused marked changes in the hepatic hemodynamics. For instance, the pressure in the hepatic vessels during stimulation rose as a rule by 13-64% depending on the site of stimulation (Fig. 1b-d). Only if the sympathoinhibitory zone or lateral preoptic nucleus was stimulated did the arterial pressure regularly fall by 16-22% of its initial value, but the pressure in the posterior vena cava and portal vein could still be increased under these circumstances (Fig. 1a).

Fragments of traces from different experiments, illustrating the reactions of the hepatic blood flow are shown in Fig. 1. The typical reaction of the portal blood flow, observed during stimulation of most hypothalamic structures, was a decrease by 10-61% (Fig. 1c, d). The reduction of the portal blood flow was particularly marked in response to stimula-

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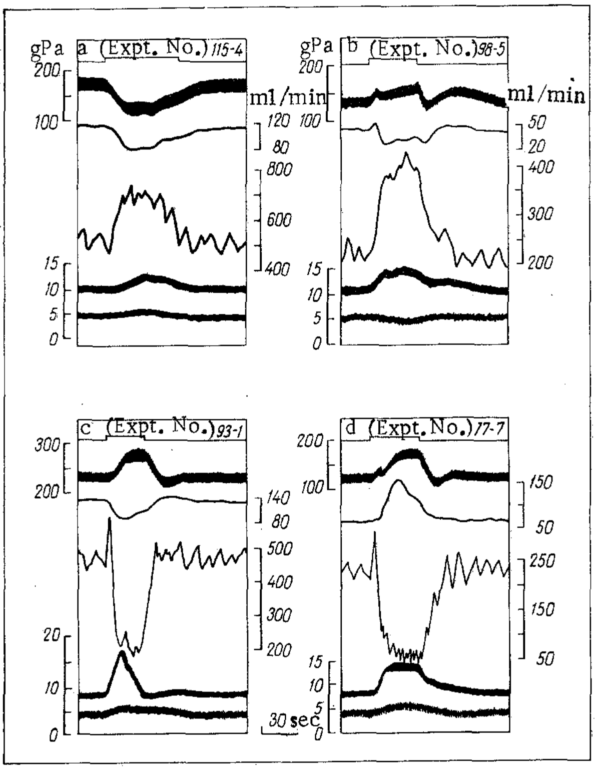

Fig. 1. Reactions of hepatic hemodynamics to hypothalamic stimulation. a) Stimulation of sympathoinhibitory zone (parameters: 0.08 mA, 4.4 V), b) stimulation of paraventricular nucleus (0.15 mA, 5.6 V), c) of medial mamillary nucleus (0.1 mA, 4.8 V), and d) of ventromedial nucleus (0.15 mA, 5.2 V). From top to bottom: marker of stimulation, arterial pressure, blood flow rate in hepatic artery, blood flow in portal vein, pressure in portal vein and posterior vena cava. Scale of pressure on left, scale of blood flood on right.

tion of the supraoptic and ventromedial nuclei. In these cases the blood flow could be reduced three-fourfold. An increase in blood flow in the portal vein as a rule took place in response to stimulation of the sympathoinhibitory zone and the paraventricular and lateral hypothalamic nuclei (Fig. 1a, b). The amplitude of these reactions was 30-56% of the original level.

The arterial circulation of the liver was increased or reduced by 21-44% during stimulation of structures of the anterior hypothalamus (sympathoinhibitory zone, lateral preoptic, anterior hypothalamic, and supraoptic nuclei); as a rule, moreover, these changes were in the same direction as changes in the arterial pressure (Fig. 1a). Meanwhile stimulation of the middle group of hypothalamic nuclei (ventro- and dorsomedial, lateral and posterior hypothalamic, lateral and medial mamillary, and paraventricular nuclei) caused changes in the arterial blood flow which were independent of changes in arterial pressure (Fig. 1b, c). The predominant type of reaction in these cases was a fall of the arterial blood flow by 33-49%.

The original values of vascular resistance in the abdominal vascular beds studied were as follows: the bed of the hepatic artery 5.66 ± 0.35 gPa/ml·min·100 g, the mesenteric vessels 0.30 ± 0.02 gPa/ml·min·100 g (the mean values of the changes in these parameters in response to stimulation of hypothalamic structures are shown in Fig. 2). Stimulation of the anterior hypothalamus was accompanied by relatively weak (14-23%) changes, mainly not statistically significant, in the resistance of the hepatic arteries. Meanwhile structures of the middle and posterior groups of hypothalamic nuclei had a stronger influence on the arterial bed of the liver: in response to their stimulation the vascular resistance in this region was increased by 60-173%. A decrease in arterial resistance in the liver also took place during stimulation of this region, but it was observed far less frequently (in 39 of 183 cases), it was small (13-21%), and not statistically significant.

The resistance of the portal and mesenteric vessels increased more than the resistance of the hepatic artery in response to stimulation of the same hypothalamic structures. There

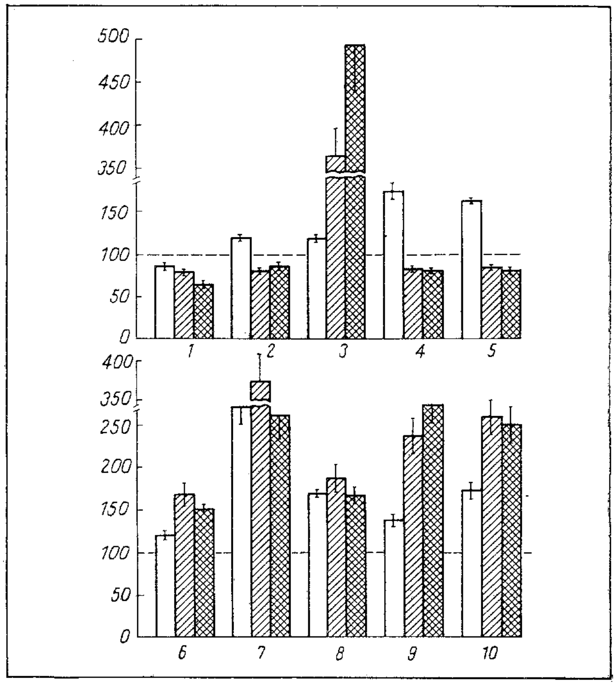

Fig. 2. Changes in resistance of hepatic vessels and of splanchnic organs during hypothalamic stimulation (in % of initial level, M ± m). Stimulation of: 1) sympathoinhibitory zone, 2) lateral preoptic nucleus, 3) supraoptic nucleus, 4) paraventricular nucleus, 5) lateral hypothalamic nucleus, 6) anterior hypothalamic nucleus, 7) ventromedial nucleus, 8) posterior hypothalamic nucleus, 9) lateral mamillary nucleus, 10) medial mamillary nucleus. Unshaded columns) resistance of hepatic artery, obliquely shaded) resistance of portal vessels of the liver, crosshatched) of mesenteric vessels.

was a particularly strong response to stimulation of the supraoptic, ventromedial, and lateral and medial mamillary nuclei. The portal and mesenteric vascular resistance in these cases was increased two-fivefold. The decrease in the resistance of these vascular beds took place in response to stimulation of the sympathoinhibitory zones and of the paraventricular and lateral hypothalamic nuclei, but the amplitude of these responses did not exceed 22% of the original resistance.

It can be tentatively suggested that the increase in resistance of the portal vessels of the liver took place on account of closure of sphincters which are present in the hepatic veins in dogs. However, as experiments using the method of rheohepatography, modified by the present writers [5] showed, the blood volume in the liver always decreased during stimulation of virtually every point of the hypothalamus, and this response took place independently of changes in the hepatic blood flow [6], i.e., in response to hypothalamic stimulation blood stored in the liver was released from it: There was no closing of sphincters and no increase in blood volume in the liver.

As already pointed out, stimulation of various hypothalamic structures causes changes in the hepatic circulation which differ in amplitude and direction. Stimulation of the same hypothalamic structures, moreover, has differential effects on vessels of different abdominal vascular beds. Stimulation of the supraoptic nucleus causes marked constriction of mesenteric and portal vessels but has only a very weak effect on the arteries of the liver, whereas in response to stimulation of the ventromedial nucleus, vasoconstriction of the portal and arterial systems of the liver is observed, accompanied by a weaker effect on the mesenteric vessels (Fig. 2).

Reactions of the hepatic circulation described above agree well with autonomic components of emotional-behavioral responses to stimulation of the same hypothalamic structures, described in the literature. For instance, stimulation of the lateral hypothalamic nucleus is accompanied by responses of food behavior, by activation of the digestive tract, and by an increase in the blood flow in it [8]. In the present experiments the portal blood flow was increased and the portal vessels of the liver were dilated. In response to stimulation of the ventromedial nucleus, a defensive reaction usually arises, with excitation of the sympathetic nervous system, an increase in the cardiac output and muscular blood flow, and constriction of the abdominal vessels [9, 15] (according to our own data, constriction of the arterial and portal vessels of the liver takes place).

Certain hypothalamic structures may therefore participate in integrative control of the hepatic circulation, by exerting well-marked, differential and, to some extent, specific influences on the hepatic vessels.

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ADRENAL FUNCTION IN *Papio hamadryas* DEPENDING ON HIERARCHICAL RANK IN AN ISOLATED GROUP

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Many research workers have devoted great attention to relations between the endocrine system and the hierarchical rank of the individual in social groups of primates. The results of such investigations, conducted on monkeys of different species, have proved fairly contradictory, evidently because different approaches to the problem were used. In polyandrous groups of primates, for example, correlation can often be traced between the rank of dominance, aggressiveness, and the level of adaptive adrenocortical hormones [3, 7]. In *Macaca rhesus*, for example, correlation can be clearly established between gregarious behavior and adrenal function. The response of the adrenals is regarded as an index of individual adaptation to the conditions of keeping in the cage [8]. On the other hand, in other investigations [5] on monkeys of the same species, the plasma cortisol concentration did not

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