EFFECT OF THE LIMBIC CORTEX ON THE REGIONAL LYMPH AND BLOOD FLOWS IN DOGS

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In acute experiments on adult dogs during electrical stimulation of the anterior part of the limbic cortex, an increase in the lymph flow from the intestinal lymphatic duct, an increase in the volume of the mesenteric lymph glands, a fall in the blood pressure in the cranial mesenteric artery, a reduction in the outflow of blood from the corresponding vein, and a decrease in the tone of the mesenteric veins were observed. Constriction of the mesenteric veins and the increase in the intestinal lymphatic flow are regarded as a compensatory response aimed at restoring the initial level of the arterial pressure as quickly as possible.

KEY WORDS: blood flow; intestinal lymph flow; mesenteric veins; limbic cortex.

The limbic cortex affects many functions of the body. Stimulation or destruction of the gyrus cinguli in animals leads to changes in autonomic functions [1, 8, 10, 11, 14]. Previous investigations showed that stimulation of this region in dogs evokes changes in the lymphatic flow from the thoracic duct, in the tone of the lymphatics, and the sugar concentration in the lymph [2, 4]. Since lymph from the abdominal organs, the trunk, and the lower limbs drains into the thoracic duct, the lymph flow from it reflects the overall effect.

The object of this investigation was to study the regional lymph flow, especially the intestinal lymph flow, and to compare it with the bloodflow in and the tone of the mesenteric veins during stimulation of the limbic region.

EXPERIMENTAL METHOD

In acute experiments on adult dogs weighing 10-16 kg, anesthetized with hexobarbital (40-60 mg/kg), the medial surface of the anterior part of the cortex was exposed and part of the opposite hemisphere removed. Square pulses (5-10 mA, 5 msec, 50 Hz) were applied for 15-30 sec to areas 24 and 32 according to the atlas of Gurevich and Bykhovskaya [5]. Recordings were made of the lymph flow from the central intestinal lymphatic duct, the volume of the mesenteric lymph glands (by the technique developed by one of the writers [3]), and the blood flow in the cranial mesenteric vein (by means of a flowmeter-pump). Changes in the volume of outflowing blood indicate the capacity of the vessels. The blood pressure in the cranial mesenteric artery, the lateral pressure in one branch of the corresponding vein, and the flow of perfusion fluid from the divided vein (perfusion with oxygenated Tyrode solution at 38°C under a pressure of 4-5 cm water); the respiration, and the intestinal movements (by means of a balloon inserted into its lumen) also were recorded.

Altogether 37 experiments, including 178 observations, were carried out.

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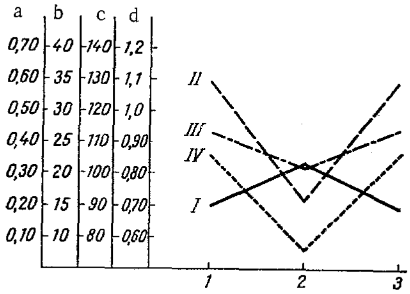

Fig. 1

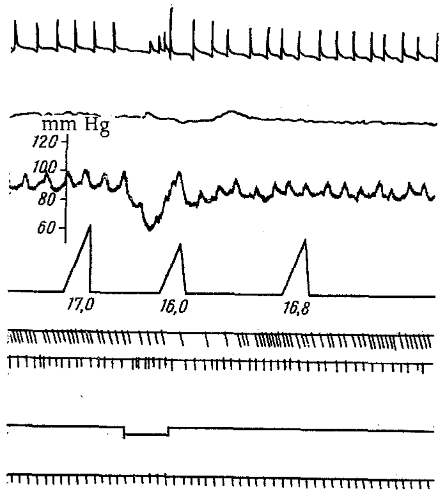

Fig. 2

Fig. 1. Graph showing changes in parameters of lymph and blood flow in mesentery during electrical stimulation of anterior part of limbic region: I) lymph flow from intestinal lymphatic duct; II) flow of perfusion fluid from segment of vein; III) blood flow from mesenteric vein; IV) arterial pressure. Abscissa: 1) before, 2) during, 3) 1.5 min after stimulation; ordinate: a) lymph flow (in ml/min), b) blood flow (in ml/min), c) arterial pressure (in mm Hg), d) flow of perfusion fluid (in ml/min).

Fig. 2. Changes in lymph and blood flow in mesentery during electrical stimulation of anterior zones of limbic cortex. From top to bottom: respiration, venous pressure, arterial pressure in mesenteric artery, volume of blood from mesenteric vein, flow of perfusion fluid from vein, lymph flow from intestinal lymphatic duct, stimulation and time markers (5 sec).

EXPERIMENTAL RESULTS

During electrical stimulation of an area of the limbic cortex surrounding the genu of the corpus callosum (area 24), an increase in the lymph flow was observed in 66% of cases, a decrease in 25%, and no change in 9%. The lymph flow rose from 0.20 ± 0.03 to 0.33 ± 0.03 ml/min ($P < 0.02$). The volume of the lymph glands was increased in 24 cases, reduced in 10, and unchanged in 6.

The arterial blood pressure was lowered in 83% of cases, on the average by 30.2 mm Hg compared with its initial level. The respiration rate was slowed and its amplitude changed. The volume of blood flowing from the mesenteric vein fell from 26.8 ± 0.08 to 20.9 ± 0.24 ml/min ($P < 0.001$). The flow of perfusion fluid from the divided vein during stimulation fell from 1.09 ± 0.15 to 0.72 ± 0.10 ml/min ($P < 0.02$). The venous pressure was increased (Figs. 1 and 2).

Electrical stimulation of an area of cortex lying basally to the cruciform fissure (area 32) caused an increase in the intestinal lymph flow from 0.15 ± 0.03 to 0.30 ± 0.07 ml/min ($P < 0.05$) and a decrease in the venous blood flow from 26.8 ± 0.24 to 22.6 ± 0.30 ml/min ($P < 0.02$). Intestinal peristalsis was unchanged in 90% of the experiments.

Stimulation of an area of cortex lying between the areas specified above led to similar changes in the intestinal lymph and blood flow. The responses were short in duration and lasted on the average 73 sec.

It will be clear from the experimental results that the intestinal lymph flow increased during stimulation of the anterior part of the limbic region. In a previous investigation [2] three functional zones, with different effects on the lymph flow, were found in the anterior part of the limbic cortex. During stimulation of the zone surrounding the genu of the corpus callosum, an increase in the lymph flow through the thoracic duct and in its lumen was observed, whereas during stimulation of another zone lying basally to the cruciform fissure, these parameters were reduced. Stimulation of the zone lying between the two above-mentioned zones gave a mixed effect: an increase or a decrease. Other workers also have mentioned the functional heterogeneity of different zones of the anterior part of the limbic region [1, 12].

In 18 cases the lymph flows from the thoracic and intestinal lymphatic ducts were recorded simultaneously. During stimulation of the first zone of the limbic region, the lymph flow from both vessels was increased; during stimulation of the second zone, the lymph flow from the thoracic duct was reduced, but that from the intestinal duct was increased.

The differences in the action of stimulation of the lymph flows from the thoracic and intestinal lymphatic ducts can be explained by differences in the response of their walls, as a result of differences in their topographic arrangement and in the realtive importance of their sympathetic and parasympathetic innervations. To this it must be added that the walls of the mesenteric lymphatics in dogs are almost without a smooth-muscle layer, whereas such a layer is well-represented in the lymphatics of the horse, goat, and man [6].

Since the contractile activity of the lymphatics is mainly connected with the presence of smooth-muscle cells in their walls, the movement of the lymph along the intestinal lymphatics to the cisterna chyli in dogs is evidently maintained chiefly by the motor activity of the smooth-muscle cells of the mesenteric lymph glands. Admittedly an influence of other factors on the lymph flow along the vessels cannot be ruled out. The very small number of smooth-muscle fibers in the intestinal lymphatics is the reason for their great extensibility and capacity, so that lymph can be stored in them if increased quantities enter these vessels. In the present experiments the volume of the mesenteric lymph glands was changed during cortical stimulation. The periodic relaxation and contraction of the lymph glands evidently create conditions favoring the storage of intestinal lymph and its transport into the lymphatic cisterns, and from them into the bloodstream.

As was stated above, stimulation of the anterior part of the gyrus cinguli led to a reduction in the outflow of blood from the mesenteric veins and in the flow of perfusion fluid, accompanied by a depressor response of the arterial pressure. These results suggest an increase in tone of the veins. Under the influence of nervous and humoral factors, veins can change their capacity [7, 9, 13].

Large quantities of blood can accumlate in the vascular bed of the mesentery. Constriction of the mesenteric veins, observed in the present experiments, leads to a rapid restoration of the initial arterial pressure level. The increase in the intestinal lymph flow and the response of the mesenteric veins to central nervous influences can be regarded as manifestations of the homeostatic function of the reservoir system of the body.

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