The Character of the Capacitance Vessel Responses in the Spleen and Intestine under Electrical Stimulation of the Sympathetic Fibres

It was shown[1-4] that the electrical stimulation of sympathetic fibres caused the constriction of both resistance and capacitance vessels in splanchnic vascular zones and in skeletal muscle. This pattern of the responses was also observed in our previous studies[5,6]. At the same time, during pressor cardiovascular reflexes the dilatation of capacitance vessels could be observed along with the constriction of resistance vessels, as was shown in our studies[5,7]. The possibility of different responses in resistance and capacitance sections of the vascular bed during pressor cardiovascular reflexes was shown in experiments of other investigators[8]. It might be suggested that the different resistance and capacitance vessel responses can occur only during cardiovascular reflexes, i.e. in situations when the vasomotor centre is involved. Meanwhile some physiological mechanisms responsible for the difference of resistance and capacitance vessel reactions could be supposed to be involved also in effects elicited by the direct activation of vasomotor fibres.

This study was intended to reveal if there was a possibility of different responses of resistance and capacitance sections of the vascular bed during the direct activation of sympathetic fibres, various frequencies of the electrical stimulation being used.

Method. The experiments were performed on cats (30) anaesthetized with urethane (1 g/kg) under artificial respiration. A spleen and a section of small intestine (jejunum and ileum) were humorally isolated and autoperfused with a constant blood volume pump. The resistance and capacitance vessel reactions were studied by the method described previously[5-7]. Response of resistance vessels were identified from the perfusion pressure changes and reactions of capacitance vessels, from the maximal value of output or restoring of venous blood. For this purpose blood was impelled with a constant blood flow perfusion pump into the vascular zone investigated; the venous outflow was directed into the recording cylinder from which the blood was returned into the venous system of animal with the second channel of the perfusion pump. Since the strone volumes of the 2 perfusion pump channels were equal and constant during the experiment, perfusion pressure changes reflected resistance vessel responses and changes of venous outflow, i.e. those of capacitance vessels. Study of shunting ability of arteriovenous anastomoses was performed by means of microspheres injections[9]. The stimulation of the splanchnic or spleen vasomotor fibres was accomplished with a right-angle impulse generator (0.25–30 imp/sec, 6 V, 5 msec). Experimental data were processed in a digital computer 'Minsk-32', the correlation and regression analyses being used.

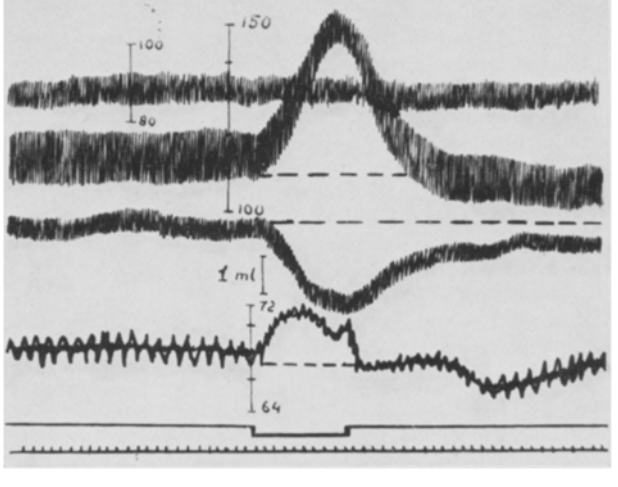

Fig. 1. The dilatatory response of the capacitance vessels and constrictory response of the resistance vessels in the small intestine under electrical stimulation (15 imp/sec, 6 V, 5 msec). Designations, records from top to bottom: systemic arterial pressure (mm Hg), perfusion pressure (mm Hg), change of the venous outflow from the intestine (ml), changes in the oxygen venous blood saturation (% HbO_2), the stimulation mark, time mark (2 sec).

Results. The electrical stimulation of intestinal vasomotor fibres produced the constriction of resistance vessels in all 18 experiments. In contrast, the capacitance vessel response was not uniform in these experiments; the vascular capacity decreased in 60% of experiments, increased in 16% (Figure 1) and was not changed in 24% of the experiments.

A similar vascular response pattern was observed in the spleen (12 cats). The electrical stimulation of spleen vasomotor fibres caused only the constriction of resistance vessels. Capacity of the spleen vascular bed decreased in 67% of experiments, increased in 21% and was unchanged in 12%.

Mathematical analyses made it possible to plot the curves, characterizing the relationships between absolute changes of the perfusion pressure and those of outflow from one side and stimulation frequency from the other (Figure 2). One can see from the diagram that the maximal resistance vessel responses were obtained with stimulation frequency of 15 imp/sec and maximal capacitance vessel responses – with stimulation frequency of 5 imp/sec. The dilatation of splenic and intestinal capacitance vessels could be elicited by electrical stimulation of vasomotor fibres with every frequency used.

The outflow changes which reflected the capacity changes in our experiments were supposed possibly to be influenced by resistance vessel responses, by capillary filtration process and by reactions of arterio-venous anastomoses. However, the analyses had not revealed a correlation between resistance and capacitance vessel responses (correlation coefficient for both the spleen and intestine being close to zero). The data of dynamics and magnitude of changes in capillary fluid exchange[3] do not support the assumption that a capillary filtration could contribute to the outflow changes observed in our experiments. In special series of experiments where microsphera technique was used, it was shown that the

[1] B. Folkov, D. H. Lewis, O. Lungren, S. Mellander and J. Wallentin, Acta physiol. scand. *61*, 445 (1964).
[2] S. Mellander, Acta physiol. scand. *50*, suppl. 176, 1 (1960).
[3] B. Öberg, Acta physiol. scand. *62*, suppl. 229, 1 (1964).
[4] K. Keller, K. Kirsch, S. Sauer, Pflügers Arch. ges. Physiol. *289*, 272 (1966).
[5] B. I. Tkachenko, D. P. Dworezky, W. I. Owsjannikov, A. W. Samoilenko and W. G. Krasilnikov, *Regional and Systemic Vasomotor Reactions* (Medicine, Leningrad 1971).
[6] B. I. Tkachenko, W. G. Krasilnikov, S. A. Polenov and G. V. Chernjavskaja, Experientia *25*, 38 (1969).
[7] B. I. Tkachenko and G. W. Chernjawskaja, Experientia *27*, 782 (1971).
[8] N. L. Browse, J. T. Shepherd and D. E. Donald, Am. J. Physiol. *211*, 1241 (1966).
[9] P. K. Pozdnjakov, Physiol. J., USSR *59*, 10 (1973).

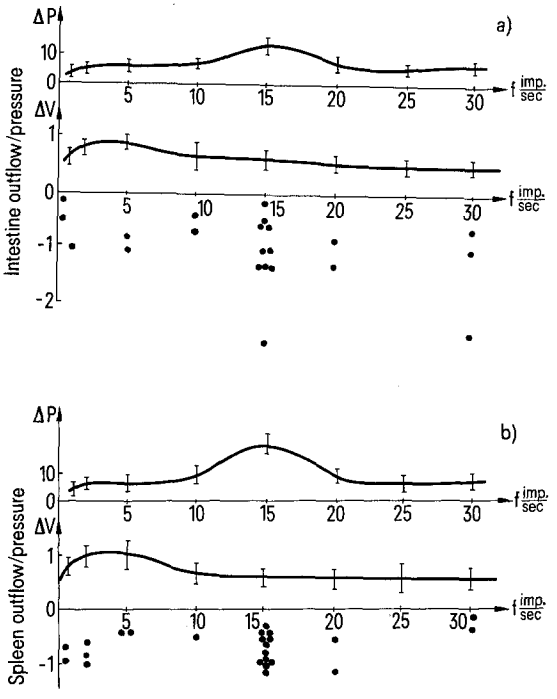

Fig. 2. The character and the magnitude of the resistance and capacitance vessel responses in a) the spleen and b) intestine under electrical stimulation of the sympathetic fibres. Abszissa, * the stimulation frequency; ordinate, * perfusion pressure changes (Δ P) and outflow changes (Δ V). The dilatatory responses of the capacitance vessels are shown as separate points.

maximal diameter of arteriovenous anasthomoses decreased under electrical stimulation of sympathetic fibres from 52 $\pm$ 4.5 μm to 34.3 $\pm$ 2.5 μm in the spleen and from 45.6 $\pm$ 1.3 μm to 32 μm in the small intestine. The microsphera shunting coefficient[9] also decreased (from 0.60 $\pm$ 0.04 to 0.50 $\pm$ 0.09 in the spleen and from 0.50 $\pm$ 0.05 to 0.20 $\pm$ 0.05 in the small intestine). These data did not allow us to explain the non-uniformity of capacitance vessel responses observed in our experiments during electrical stimulation of the sympathetic fibres, by changes in arteriovenous anasthomosis flow.

Conclusions. 1. Both constrictory and dilatory response of the spleen and intestine capacitance vessels could be observed under electrical stimulation of the vasomotor fibres, resistance vessel response being always constrictory. 2. The uniformity of the capacitance vessel responses was not due to the resistance vessel responses, capillary filtration and changes in arteriovenous anastomosis flow.

ВЫВОДЫ. При электрической стимуляции симпатических нервов на фоне констрикции резистивных сосудов тонкого кишечника и селезёнки могут проявляться как констрикторные, так и дилататорные реакций емкостных сосудов. Характер реакций емкостных сосудов тонкого кишечника и селезёнки в этом случае не зависит от величин реакций резистивных сосудов, фильтрации жидкости и пропускной способности артерио-венозных анастомозов.

B. I. TKACHENKO, N. JA. MEDVEDEVA and P. K. POZDNJAKOV

Institute of Experimental Medicine, Laboratory for Circulation, Kirovsky pr. 69/71, Leningrad P-22 (USSR), 24 January 1974.

Is There a Special Pacemaker for Stepping?

Recently 'locomotor discharges' were obtained in the anterior ventral roots of motionless decorticated animals. On the basis of this fact, a hypothesis of a special supraspinal 'locomotor pacemaker' was formulated[1]. In fact, as shown in our present paper, there is no special pacemaker for stepping. The rhythmical discharges which are registered in the spinal ventral roots of motionless animals are provoked by the respiratory centre.

Methods. Experiments were performed on 5 adult cats decorticated under ether anaesthesia. These cats had been used in our previous experiments devoted to investigation of the mechanisms of locomotion[2–4]. The dorsal and ventral roots (S_1–L_6) and the phrenic nerve were intersected. The electrical activity was recorded simultaneously in the central part of the phrenic nerve and in the filaments of the ventral root. Complete motor paralysis was produced by i.v. injection of Flaxedil (4–5 mg/kg). Artificial respiration was performed through a tracheofissura. The volume of the respiratory pump was 25–30 ml, the frequency 30 per min. Asphyxia was evoked by an arrest of artificial respiration for 2–3 min, hyperventilation by increasing the volume of the respiratory pump up to 50–60 ml.

Results and discussion. In the records A, B and C (Figure) the electrical activity from the filament of the spinal ventral root (S_1) and the phrenic nerve were recorded during complete motor paralysis produced by i.v. injection of Flaxedil.

Records A were obtained during normal artificial ventilation. The discharges in the filament of the ventral spinal root (A_1) are in accordance with the discharges of the phrenic nerve (A_2). The discharges of the ventral root filaments appear in the interval between the inspiratory discharges of the phrenic nerve. In other experiments, the discharges in the ventral roots may appear simultaneously, before or after the inspiratory discharges of the phrenic nerve. This probably depends on the following: to produce stepping, the discharges of different ventral roots which innervate distinct muscles must appear in strict succession. Therefore the interval between the discharges of the phrenic nerve and the ventral root filaments may differ. But the correlation between them is a rule constant.

Records B were obtained during the arrest of the artificial ventilation. In accordance with the hypercapniae evoked by asphyxia inspiratory, discharges of the phrenic

[1] C. PERRET, M. MULLENVOGE and A. CABELCUEN, J. Physiol., Paris *65*, 153 (1972).
[2] S. I. FRANKSTEIN, M. B. RECHTMAN and V. V. LISIN, Int. Res. Commun. *16*, 21 (1973).
[3] V. V. LISIN, S. I. FRANKSTEIN and M. B. RECHTMAN, Int. Res. Commun. *16*, 20 (1973).
[4] V. V. LISIN, S. I. FRANKSTEIN and M. B. RECHTMAN, Expl Neurol. *38*, 180 (1973).