# COMPARATIVE HEMODYNAMICS OF THE RIGHT AND LEFT COMMON CAROTID ARTERIES IN CATS

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The possibility of specific structural and functional differences in the organization of the blood supply to the cortex of the right and left cerebral hemispheres has not been seriously discussed in the literature. In connection with the problem of asymmetry of the brain attention has been drawn mainly to quantitative relations between the blood supply to the hemispheres as indicators of the level of their functional activity [3, 10, 11]. Meanwhile, if the argument is taken beyond the limits of a single "functional element," matching of the level of blood supply with the level of activity of a tissue can be achieved by various vascular mechanisms, as is reflected by the time course of vasomotor changes [5]. The elucidation of these mechanisms is important especially for clinical practice [9], for it would help to reveal the conditions of development of regional cerebrovascular pathology. There is no doubt also that it would broaden our ideas on interaction between brain systems.

Data obtained by comparing the microvascular system of the cortex of the two hemispheres are extremely scarce [6, 12, 13] and, although signs of "vascular asymmetry of the brain" have been found in cats and rats, they do not yet allow the basic properties of these vascular regions as a whole to be compared. The writers showed previously that parameters of the pulsatile flow, the volume velocity of the blood flow, and their response to catecholamines differ in the right and left common carotid arteries in cats, reflecting heterogeneity of the functional properties of the arteries or of their territories of distribution, which include the vascular regions of the cortex of the ipsilateral hemispheres.

To continue the analysis of the specific features of function of these territories, characteristics of the blood flow in the right and left common carotid arteries of cats were investigated and their correlation with the basic parameters of the systemic hemodynamic was investigated in various static states before and after repeated injections of adrenalin and noradrenalin.

## EXPERIMENTAL METHODS

Parameters of the volume velocity of the blood flow (VB), the diastolic blood (DB), and systolic blood flow (SB), and parameters of the systemic hemodynamics (SH), namely blood pressure (BP) and heart rate (HR), was subjected to multiple correlation analysis (MCA). The analysis was then extended to the same parameters recorded in nine animals 15-20 min after 1-4 repeated injections of adrenalin (A) in increasing doses (form 2 to 10 μg/kg), and again after 1-3 injections of noradrenalin (NA) in the same order (60 positions altogether). The time of recording was determined by stabilization of the parameters after the procedures. Initial values of SH and VB for the group of nine animals were compared for limits of variability, average values, and character of distribution with the hemodynamic status of the total population studied.

Dependence of VB in the right (RVB) and left (LVB) common carotid arteries on BP and HR were investigated by regression analysis with approximation by a third degree polynomial,

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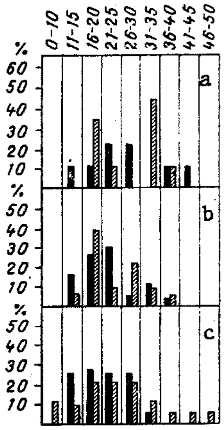


Fig. 1. Histograms of distribution of values of volume velocity of blood flow in right and left common carotid arteries. Abscissa, top – ranks of values of volume velocity (in ml/min); ordinate, % of total number of cases. a) In initial state; b) after injection of NA. Black columns) right artery; obliquely shaded) left artery.

separately for states arising after injections of A (34 positions) and after injections of NA (26 positions). The results were subjected to statistical analysis by Student's test for tied pairs. The significance of approximation was estimated by Fisher's test. MCA was carried out and regression graphs plotted by "Olivetti 6060" computer.

## EXPERIMENTAL RESULTS

MCA showed a weak tendency toward negative correlation of VB in the right and left common carotid arteries of anesthetized animals in the initial state, in the absence of any additional procedures. After injection of the catecholamines (CCA) correlation between RVB and LVB was completely absent. It was shown previously [7] that in the presence of weak changes in SH in response to injection of CCA, synchronously recorded changes in VB in the arteries did not correlate throughout the period of the responses, and not until the pressor effect of CCA was intensified did positive correlation between RVB and LVB increase. Subsequently, therefore, we shall examine the characteristics of the blood flow in the arteries and their correlation with the parameters of SH separately.

Initial values of SH and VB of the animals investigated were described in detail previously [7]. After injections of A the limits of variation of BP and HR widened, to 80-168 mm Hg (compared with initial values of 110-160 mm Hg) and 96-281 beats/min (initially 112-261 beats/min), but after injections of NA they changed no more. A tendency was noted for average values of BP to fall after the procedures (140 mm Hg initially, 135 mm Hg after injections of A, 127 after injections of NA), and for the mean values of HR to rise (173 – 180 – 190 beats/min, respectively).

Whereas the total peripheral resistance evidently showed no significant changes after injection of CCA, resistance in the territories of the carotid arteries rose sharply, for VB fell in the right artery from 24.11 ± 3.11 ml/min to 15.81 ± 1.73 ml/min; in the left artery it fell from 32.04 ± 2.89 to 22.52 ± 2.45 ml/min, respectively (for both comparisons $p < 0.001$). The decrease in RVB was entirely due to a fall of DB, whereas SB was virtually unchanged. Both components of the pulsatile flow participated in the decrease in LVB: SB fell significantly from 64.32 ± 5.24 to 55.26 ± 4.41 cm/sec ($p < 0.01$).

The distribution of the values of RVB and LVB changed in opposite directions (Fig. 1), and on the whole it widened for the left and narrowed for the right artery. Characteristically, the lower limit of the distribution in the right artery did not shift. This evidently means that vasoconstriction in the right territory is maximal in the initial state already. Repeated injections of CCA increased the resistance of the arterial bed on average, abolishing dilated states of the vascular bed. The effect of repeated injections of CCA on LVB was indeterminate. With an increase in resistance of the arterial bed, on average NA induced a significant increase in variability and dispersion of VB, thus approximating the state of the territory of distribution of the left artery to the initial state of the right.

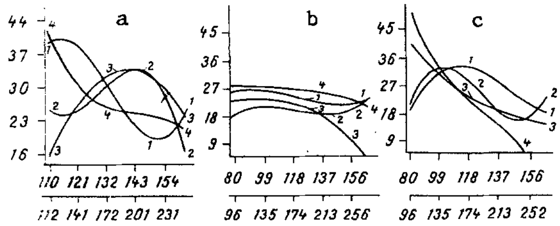

Fig. 2. Regression dependence of RVB and LVB on BP and HR. Abscissa: top – BP (in mm Hg); bottom – HR (beats/min); ordinate, VB (in ml/min). a) In initial state: 1) dependence of RVB on BP, 2) on HR, 3) dependence of LVB on BP, 4) on HR; b) in right artery, c) in left artery after injection of CCA: 1) dependence of VB on BP after injections of A, 2) after injections of NA, 3) dependence of VB on HR after injections of A, 4) after injections of NA.

Turning to the results of MCA, it will be noted that they reveal stronger dependence of RVB on DB than on SB, both in the initial state and after the injections, but this was not observed in the left artery, where VB depended equally on SB and DB. Similar relationships were noted also by the writers when examining the distribution of RVB and LVB and in responses to procedures [7]. Demonstrated by different methods of analysis and in different states of the territories of distribution, these relationships evidently characterize sufficiently well marked and lasting differences. We suggest that these differences be interpreted as evidence of the greater involvement of the peripheral portions of the bed of the right artery and arterioles in regulation of the blood supply to the territory.

According to the results of MCA the blood flow in the left artery was invariably connected by a many times stronger negative dependence on HR than RVB. In the right artery negative correlation with BP was stronger initially. These relationships were next studied by regression analysis. It will be clear from Fig. 2a that in the initial state dependence of RVB on BP (line I) has the characteristic appearance for autoregulation with an element of "overregulation," which was particularly marked in the region of lower BP. Dependence of LVB on HR was close to that described above (Fig. 2a: 4). The RVB/HR and LVB/BP relationships are evidently passive, and the lines reflecting these dependences (Fig. 2a: 2 and 3) likewise almost coincide. Thus the parameters of SH which actively interact are evidently BP with the territory of the right, and HR with that of the left artery.

Dependences of VB on parameters of SH in the bed of the right artery after injections first of A, and later of NA, are shown in Fig. 2b. Clearly after injection of CCA the "overregulation" was abolished in the low pressure region: the lines showing dependence of RVB on BP (Fig. 2b: 1 and 2) are evidence of complete parameter. It is interesting to note that CCA facilitate "autoregulation" in the territory of the right artery relative to HR also (Fig. 2b: 3 and 4). It will be clear from Fig. 2c: 1 and 2, that although CCA potentiate the autoregulation properties of the left territory compared with the initial state, nevertheless a passive relationship to this parameter is preserved in the low pressure region.

After injections of A and, in particular, of NA, the regulatory effect of HR in the territory of this artery is enhanced (Fig. 2c, lines 3 and 4). The extremely high significance of the approximation for these dependences will be noted, for the values of "p" were $4^{-5}$ and $2^{-7}$, respectively, i.e., the scatter of the data relative to these curves was virtually nonexistent at all 60 positions examined. It can be concluded from statistical analysis of all the regression lines that LVB is determined by at least an order of magnitude more by the parameters of SH than by RVB. The variability of RVB is more spontaneous in character, and the hemodynamic situation in the right artery is demonstrably more stochastic.

Two types of barogenic reactions are currently differentiated, without reference to the blood supply of the brain: a static component of intravascular pressure, realized by small arterioles, and a dynamic component – pulsations of pressure, represented in large arteries and in more "convoluted" networks [8]. The correlations with BP and HR enable regulation of RVB to be connected with the first of these mechanisms and regulation of LVB with the second. It has been pointed out [2] that NA changes the type of barogenic responses of large arteriess. This is in agreement also with our own results. Phenomena such as dependence of the reactions to injection of CCA on the initial state of DB [7], and the greater spontaneous variability of VB, which is evidently based both on automaticity of the myocytes of the arterioles and on the comparatively minor role of its "input" element, the artery itself, in maintenance of the constancy of the blood supply to the territory of distribution also are in agreement with the dominant regulatory influence of small arterioles in the territory of the right artery. The relatively important role of DB in the formation of the hemodynamic situation in the right artery also becomes understandable from these standpoints, and confirms the view expressed previously on the connection between DB and the peripheral resistance of the territory of distribution. It is stated in the literature that myogenic autoregulation is exhibited more strongly in the right than in the left parietal region in cats [14]. If the artery itself and the peripheral part of its bed participate equally in the regulation of the blood supply to the territory of the left artery, which is compatible with the more synergic behavior of SB and DB, the structure of the microvascular portion ought to differ from that in the territory of the right artery. Previously, by intravital morphometric analysis, the writers demonstrated the greater relative extent of the pial network in the left parietal zone of cats than in the right [6]. Thus the specific nature of the hemodynamic situation in the common carotid arteries evidently reflects differences in the blood supply to the hemispheres. The question of how far this is determined by local regulatory influences on the cerebral vessels, and how far it is connected with factors of the central hemodynamics, can be settled by comparison of the dynamic characteristics of the blood supply to other vascular regions, belonging to territories of the common carotid arteries. In view of the anatomical pecularities of the system supplying blood to the cerebral cortex in cats [1], the possibility of extrapolation of the results cited above is limited. Nevertheless it must be noted that the different relationships of the territories of the common carotid arteries to BP and HR constitute a highly expedient mechanism for ensuring additionally an adequate blood supply to the hemispheres to meet the whole diversity of behavioral and motor responses, accompanied by a broad spectrum of "patterns" of changes in SH and a more flexible level of blood supply to the right hemisphere, which is connected with the evaluation of space and with emotional manifestations.

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