Microvessels of Hamster Buccal Pouch under Conditions of Reduced Systemic Blood Pressure

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Using implanted camera we studied hamster buccal pouch microvessels under conditions of reduced blood pressure. The correlation (R=0.30-0.85) between the diameter and pressure was observed in 42% vessels. During progressive decrease in blood pressure, R for the majority of left venules was below zero, while left arterioles had equal probability of having R<0 and R>0. For right venules the positive and negative correlations were equally probable, while right arterioles were predominantly characterized by R>0. Heterogeneous reactions in microvessels of different diameter were revealed.

Keywords: *microvessels; pressure; correlation; hamster buccal pouch; asymmetry*

The microcirculatory bed (MCB) is strongly protected from changes in perfusion pressure, particularly in the brain, heart, and kidneys. This protection is determined by the corresponding variations in vascular resistance: vascular resistance increases during elevation of blood pressure, but decreases during its reduction. Much attention is paid to the mechanisms of adaptation to transmural pressure [4], role of basal tone [3], effect of structural organization in the bed [7,9], variations in the reaction of microvessels [1,2,5,6,8], and mathematical modeling of structural adaptation in the vascular network [9]. Here we studied adaptation of microvessels in hamster buccal pouches to reduced blood pressure.

MATERIALS AND METHODS

Experiments were performed on 10 male hamsters weighing 140-150 g. The animals were narcotized with nembutal in a dose of 9 mg per 100 g body weight. Biomicroscopy of vessels was performed using an implanted camera (magnification 7×9 or 7×26). Microvessels were photographed. Negatives were scanned and analyzed by Image Tool software to estimate the diameter of microvessels. Blood pressure was measured in the contralateral carotid artery. A catheter was inserted into the right carotid artery of animals with left-pouch camera, and vice versa. The decrease in blood pressure was produced by intramuscular injection of 2% papaverine in a dose of 0.3 ml per 100 g body weight. Papaverine-induced changes were monitored over 40 min. Observations were continued for 40 min after intramuscular injection of 10% caffeine in the same dose. Changes in blood pressure were continuously monitored using a MRI-05 electromanometer (San-EI 142-8 polygraph) and ink recorder. The vessels were photographed at 3-5-min intervals. The correlation between the pressure and diameter of microvessels was evaluated using Statistica software.

RESULTS

Variations in the diameter of microvessels differed in the left and right pouches and were more significant on the right side (Table 1). Significant pressure drop (54-55.5% of the basal level) was observed only after consecutive treatment with two preparations (Table 2). Blood pressure in the left and right carotid arteries decreased by 23.6 and 12.2%, respectively, after papaverine administration. Blood pressure in the left and right carotid arteries underwent similar changes, parti-

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TABLE 1. Diameter of Microvessels in Hamster Buccal Pouches before Testing

Parameter	Left pouch		Right pouch	
	venules	arterioles	venules	arterioles
Diameter	61.6±19.8	42.3±7.5	63.2±28.7*	45.4±14.6*
Number of vessels	44	11	55	23
Range	(25-105)	(25–90)	(25-150)	(25-115)

Note. *$p<0.05$ compared to the left pouch (Fischer's test).

cularly after administration of papaverine and caffeine. Blood pressure in the left and right carotid arteries was 0.333-0.592 and 0.303-0.610 of the basal level, respectively. These data allowed us to compare the characteristics of microvessels. However, considerable variability in blood pressure (Fig. 1) and dia-

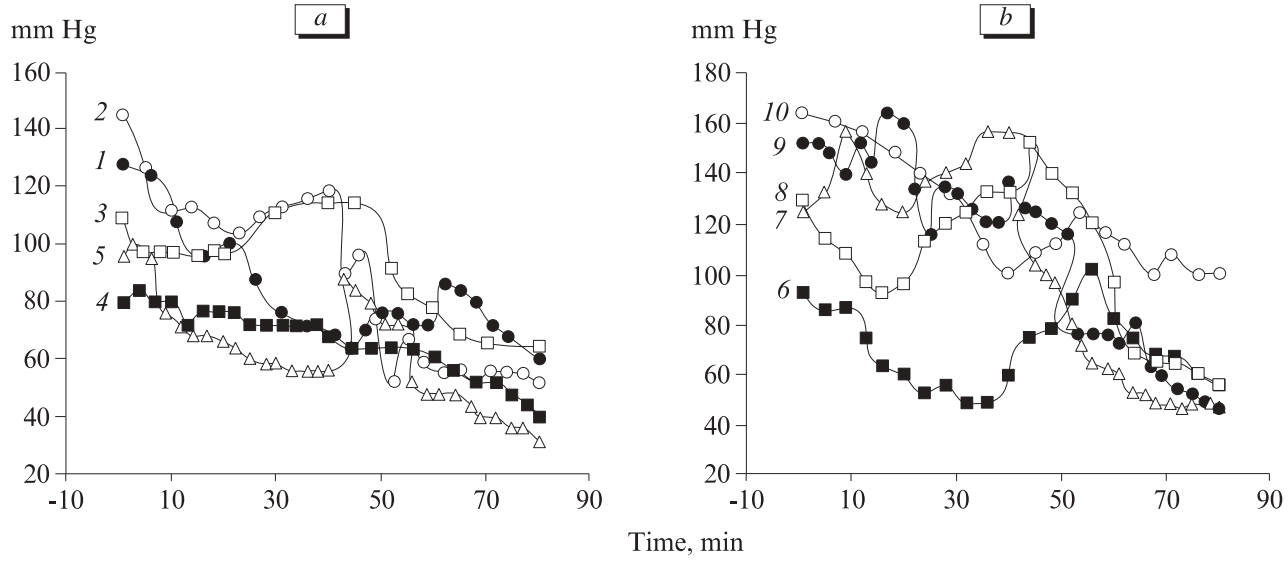

Fig. 1. Blood pressure in the left (*a*, *1-5*) and right carotid arteries of hamsters (*b*, *6-10*) under conditions of reduced systemic pressure (papaverine, first 40 min; caffeine, follow-up period).

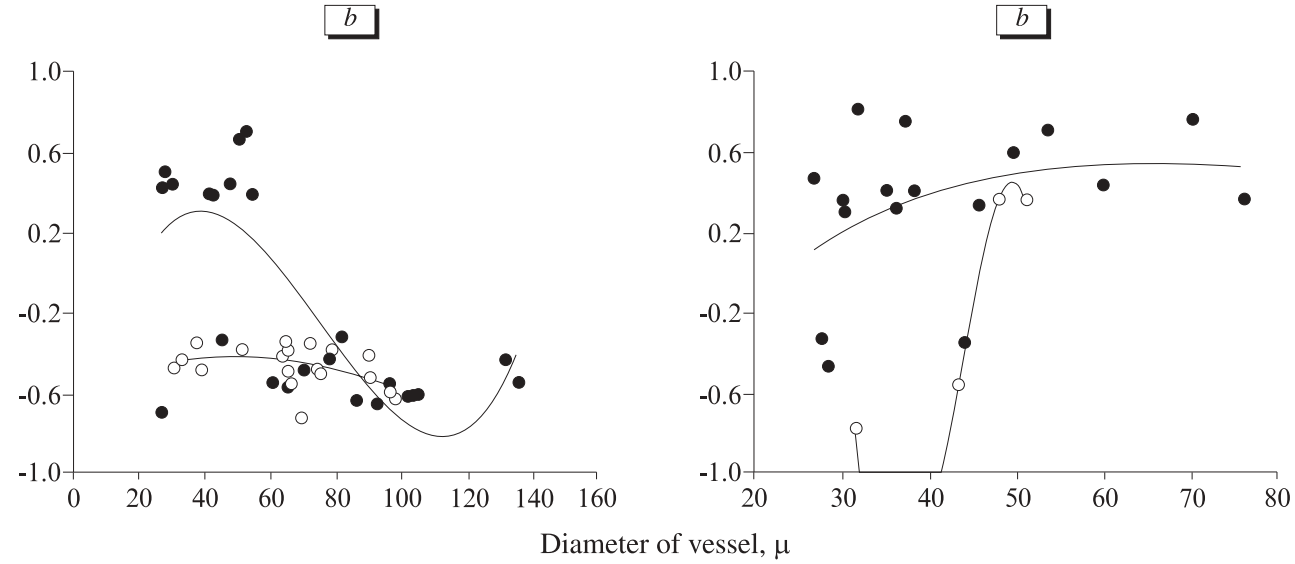

Fig. 2. Coefficients of correlation between the diameter of microvessels in the microcirculatory bed of hamster buccal pouch and pressure in the contralateral carotid artery. Third-degree polynomial approximation of curves. Here and in Fig. 3: venules (*a*) and arterioles (*b*). Light circles, left vessels; dark circles, right vessels.

TABLE 2. Blood Pressure in Hamster Carotid Arteries after Consecutive Administration of Papaverine and Caffeine

Parameter	Time, min								
	basal conditions	5	10	15	20	25	30	35	40
Left carotid artery									
Diameter	111.4±22.8	95.2±17.6	86.4±15.5*	83.1±15.2*	85.3±17.5	81.0±23.3	86.6±22.8	87.5±31.5	82.2±24.6*
Number of measurements	5	12	8	7	5	3	5	2	9
Right carotid artery									
Diameter	132.1±24.7	129.2±26.2	111.8±33.6	120.8±38.2	121.5±35.5	112.7±45.8	110.4±35.1	106.8±30.5	109.2±27.1
Number of measurements	5	13	9	5	5	3	5	8	4
	Time, min								
	basal conditions	45	50	55	60	65	70	75	80
Left carotid artery									
Diameter	111.4±22.8	75.2±11.4*	70.0±12.9*	69.2±8.4*	67.3±8.4*	56.6±10.7*	55.9±15.6	56.0±10.7	56.5±15.6
Number of measurements	5	11	6	5	5	3	5	6	10
Right carotid artery									
Diameter	132.1±24.7	114.0±24.2	88.8±25.7*	94.2±27.9*	79.4±22.7*	76.0±20.0*	79.5±21.4*	73.3±17.8*	69.6±17.4*
Number of measurements	5	14	10	7	4	4	4	6	10

Note. Mean deviation and standard deviation (mm Hg). 5-40 min: after papaverine administration; 45-80 min: after caffeine administration. *$p<0.05$ compared to the basal level.

TABLE 3. Correlation between vessel diameter and pressure under conditions of reduced systemic pressure

R	Papaverine, 40 min (left pouch, left pressure)		Papaverine, 40 min (right pouch, left pressure)	
	venules	arterioles	venules	arterioles
R>0	2 (0*)	3 (0*)	14 (4*)	12 (5*)
R<0	15 (3*)	3 (1*)	12 (2*)	4 (1*)
	After administration of caffeine, 40 min			
R>0	2 (1*)	5 (3*)	13 (4*)	10 (5*)
R<0	19 (6)	1 (0)	12 (7)	6 (1)
	Total period of systemic blood pressure variations			
R>0	0	2 (2*)	11 (5*)	14 (6*)
R<0	21 (10*)	2 (2*)	16 (1*)	3 (1*)

Note. Number of microvessels with $R \geq 0.3$. *Significant correlation.

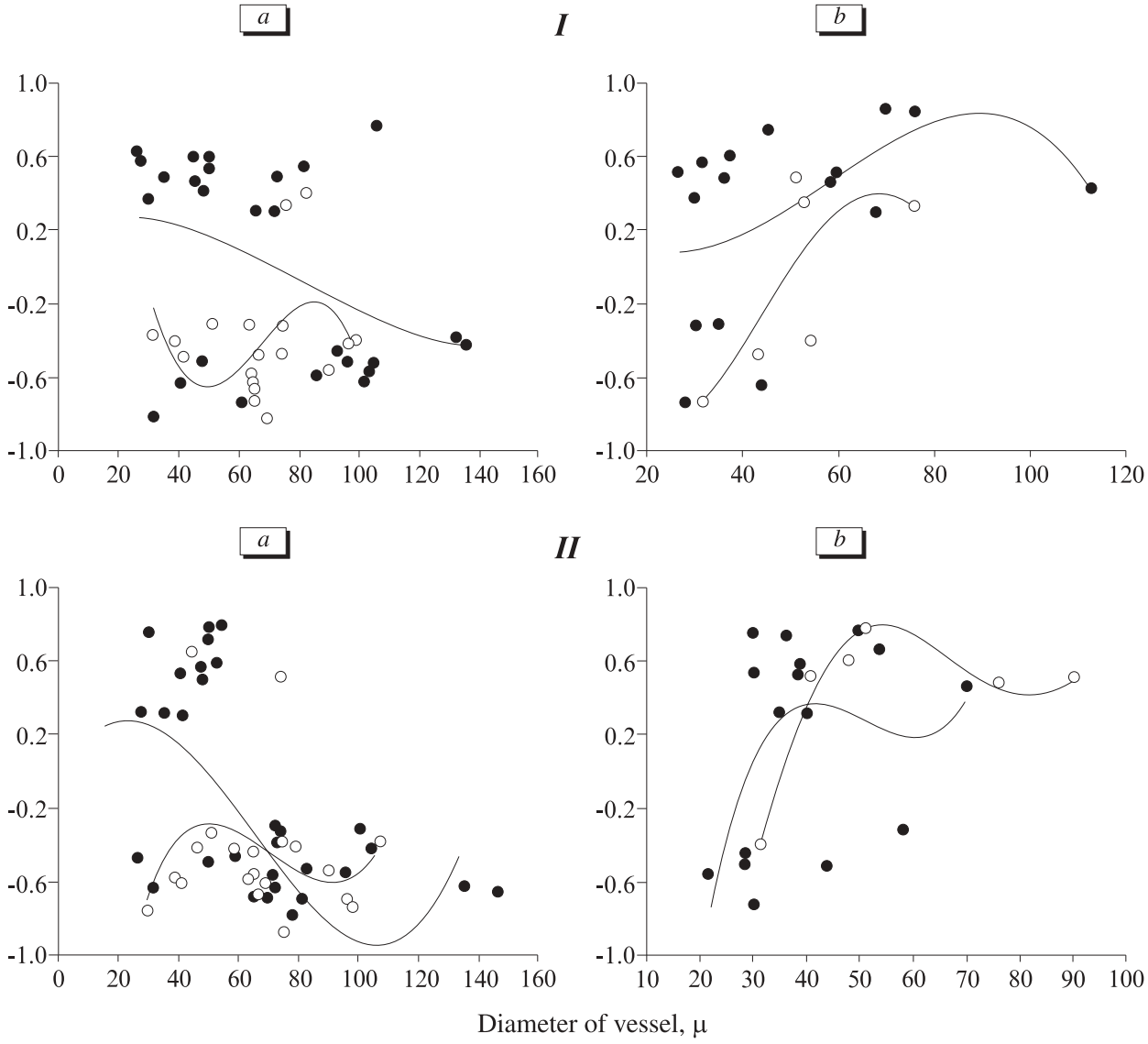

Fig. 3. Correlation between pressure and size of microvessels. Period 1: 1-40 min after administration of preparations (*I*). Period 2: 40-80 min after administration of preparations (*II*).

meter of microvessels was revealed for each hamster. Therefore, the pressure-diameter relationship was evaluated by the coefficient of correlation between these parameters (R) for individual microvessels in each series of experiments. The mean change was estimated. This approach adequately reflects the state of microvessels. The sign of R illustrates unidirectional ($R>0$) and opposite changes in the diameter of microvessels ($R<0$): its decrease at reduced pressure (vasoconstriction) and increase in the diameter at elevated pressure (vasodilation), respectively.

The correlation coefficient was above 0.3 only in 42% microvessels (Table 3). We calculated the percentage of "active" venules and arterioles on the left (47.7 and 36.4%, respectively) and right side (49.1 and 73.4%, respectively). The correlation coefficient (R) for left venules was below zero after the reduction of blood pressure. Left arterioles had equal probability of having $R<0$ and $R>0$. The positive and negative signs of correlation were equally probable for right venules. Right arterioles were predominantly characterized by $R>0$ (constriction of arterioles after the reduction in systemic blood pressure). The ratio between microvessels exhibiting constriction and dilation remained practically unchanged in the overall period of observations and after administration of papaverine or caffeine. The specific reaction of venules and arterioles with different diameter was studied in further experiments.

The correlation coefficient for left venules with an initial diameter of 20-100 μ was below zero. The correlation coefficient for arterioles underwent considerable variations on the left side. Left arterioles with a diameter of 20-45 μ had the correlation coefficient of below zero. However, the correlation coefficient for left arterioles of greater diameter was above zero. Right venules of MCB with a diameter of 20-55 and 60-130 μ were characterized by $R>0$ and $R<0$, respectively. The correlation coefficient for right arterioles with a diameter of 20-80 μ was above zero (Fig. 2).

The reaction of microvessels was studied in various periods after treatment with the preparations. The correlation coefficient for left venules was below zero under basal conditions (dilation). Changes in the diameter of vessels contribute to the increase in outflow and preservation of inflow (Fig. 3). It should be emphasized that the first disturbances occurred in venules (particularly, in distal venules). These venules facilitate outflow, maintain inflow and, therefore, operate under unfavorable conditions. The impairment of blood flow in venules is followed by circulatory disturbances in arterioles and significant alteration of outflow. Right vessels exhibited various reactions under basal conditions. The first disturbances were observed in arterioles. Most arterioles had the correlation coefficient of above zero. Variations in blood pressure produced a change in blood flow (Fig. 3). Even small changes in blood flow in arterioles were accompanied by severe circulatory disturbances in venules.

Thus, we first demonstrated regularities in the reaction of microvessels in paired organs to reduction in systemic blood pressure.

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