myocardial infarction, including the onset of ventricular fibrillation and its precursors. This is evidence that the system of endogenous opioid peptides may be involved in the response of the body to acute myocardial ischemia. One of the adaptive, corrective mechanisms preventing the onset of lethal arrhythmias when the blood supply to the heart muscle is disturbed may evidently be connected with this possibility. It is not impossible that the increase in the frequency of development of ischemic cardiac arrhythmias after preliminary injections of naloxone is also connected with the blockage of opiate receptors mediating the antinociceptive action of opioid peptides at the spinal cord level [15] and with activation of sympathetic influences on the myocardium.

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TRANSIENT ISCHEMIA EVOKED BY PARTIAL CORONARY ARTERIAL OCCLUSION IN CONSCIOUS IMMOBILIZED RABBITS

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KEY WORDS: myocardial ischemia; occlusion of the coronary artery

It is usually considered that in the presence of marked myocardial ischemia the coronary reserve is exhausted. However, recent experiments on dogs [3, 5] have shown that in the presence of functionally significant ischemia and a low perfusion pressure, the coronary dilatation reserve is preserved and may be detected by means of adenosine. The aim of the present investigation was to study changes in the coronary blood flow and vascular resistance during partial occlusion of a large coronary artery in conscious immobilized rabbits.

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TABLE 1. Basic Parameters of Systemic Hemodynamics and Myocardial Blood Flow in Conscious Rabbits (n = 8) and Their Changes Induced by Immobilization

Parameter	Initial level	Changes during 30 min of immobilization
Mean blood pressure, mm Hg	77 ± 4	24 ± 5*
Heart rate, beats/min	300 ± 14	23 ± 9*
Cardiac index, ml/(min·kg)	232 ± 13	−53 ± 20*
Total peripheral resistance (mm Hg/ml/min/kg)	0.35 ± 0.04	0.23 ± 0.07*
Regional blood flow, ml/(min·g):		
Right ventricle	2.52 ± 0.35	−0.45 ± 0.19*
Left ventricle	4.07 ± 0.41	−0.15 ± 0.25
Regional vascular resistance, mm Hg/ml/min/g:		
Right ventricle	35 ± 5	21.8 ± 0.74*
Left ventricle	20 ± 2	8.4 ± 0.25*

Legend. *$p < 0.05$ compared with initial level.

EXPERIMENTAL METHOD

Experiments were carried out on male chinchilla rabbits weighing 2.5-3.5 kg. Parameters of the systemic and regional hemodynamics were studied with the aid of microspheres (15 μ, "NEN, USA), labeled with radioactive isotopes, as described in detail previously [1]. A catheter and a device for creating measured occlusion of the coronary artery was implanted into the left atrium 48-72 h before the experiment began [2]. A tape was passed under the anterior descending branch of the left coronary artery in its middle third by means of an atraumatic needle. One end of the tape was securely fixed to the platform of the occluder, whereas the other was passed through the interior of a tube with screw thread. The peripheral end of the catheter and part of the occluder with the thread were exteriorized. The arterial catheter was introduced (under local anesthesia with 2% procaine solution) into the abdominal aorta through the femoral artery immediately before the experiment in order to record blood pressure and to take blood samples.

The blood pressure was measured in the course of the experiment with an electromanometer. The ECG was recorded in precardial derivations. All parameters were recorded on a "Mingograf-82 automatic writer. About 150,000 microspheres were injected into the left atrium in the form of a suspension in 10% dextran solution with 0.05% Tween-80. To determine the cardiac output and regional blood flow, 5 sec before the beginning of injection of the microspheres, a blood sample was taken from the aorta at the rate of 1.5 ml/min for 2 min. After injection of the last portion of microspheres the animals were killed with an overdose of pentobarbital. The left ventricle was separated from the right and from the atria, and frozen for 30 min at −20°C. The left ventricular myocardium was then divided from base to apex into four circular segments, each 5 mm wide, and each layer was divided into subendocardial and subepicardia. Part of the septum facing the cavity of the right ventricle was included with the subepicardial layer. The number of microspheres in the myocardium was counted on a type 1282 Compu-Gamma gamma-counter (LKB-Wallac, Finland). The rabbits were fixed by their limbs to a frame in the supine position. After adaptation for 30 min, the first portion of microspheres was injected. After 10 min the lumen of the coronary artery began to be reduced by turning the head of the screw through 36° every 5 sec. The screw was turned until the appearance of signs of ischemia on the ECG

TABLE 2. Parameters of Systemic Hemodynamics and Myocardial Blood Flow in Conscious Immobilized Rabbits (n = 6) before, during Development, and after Disappearance of Ischemic ECG Changes during Measured Occlusion of Anterior Descending Branch of Left Coronary Artery

Parameter	Before occlusion	During occlusion	
		at 1st minute	after normalization of ECG
Mean blood pressure, mm Hg	88 ± 2	77 ± 4*	78 ± 4*
Heart rate, beats/min	303 ± 15	322 ± 17	292 ± 14**
Cardiac index, ml/(min·kg)	174 ± 13	178 ± 27	203 ± 30**
Total peripheral resistance (mm Hg/ml/min/kg)	0.52 ± 0.03	0.48 ± 0.07	0.42 ± 0.05*
Regional blood flow, ml/(min·g):			
Right ventricle	2.46 ± 0.47	3.20 ± 0.42*	3.30 ± 0.37*
Left ventricle			
Intact zone (segments I and II — base of the heart), subepicardium	2.31 ± 0.31	3.52 ± 0.63	3.29 ± 0.50*
Subendocardium	3.19 ± 0.47	4.56 ± 0.73	4.04 ± 0.60
Boundary zone (segment III — position of occluder)			
Subendocardium	3.51 ± 0.51	4.00 ± 0.77	4.64 ± 0.54
Subepicardium	3.50 ± 0.37	3.12 ± 0.64	4.18 ± 0.58**
Zone of ischemia (segment IV — apex of heart)			
Subepicardium	3.84 ± 0.52	2.00 ± 0.49	5.05 ± 0.67**
Subendocardium	3.80 ± 0.46	1.46 ± 0.45*	4.78 ± 0.77**

Legend. *$p < 0.05$ relative to initial level; **$p < 0.05$ relative to 1st minute of occlusion.

(elevation of the ST segment by 0.1 mV above the isoelectric line or the appearance of high-amplitude T waves), after which an additional turn through 360° was made and the second portion of microspheres injected. The third portion of microspheres was injected at the moment when

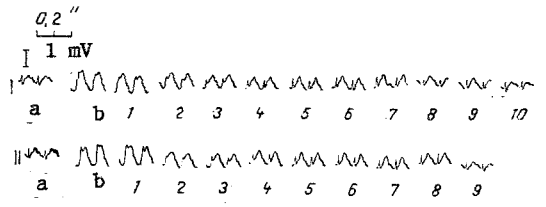

Fig. 1. ECG changes (precordial leads) in two experiments with partial occlusion of anterior descending branch of left coronary artery in conscious immobilized rabbits. a) Initial ECG; b) ECG changes during above-threshold occlusion; 1-10) time intervals (in min) corresponding to time of recording ECG.

the ST segment returned to the isoelectric line. The numerical results were subjected to statistical analysis by Student's paired t test. The results are presented in the form M ± m.

EXPERIMENTAL RESULTS

Data showing the effect of immobilization stress on parameters of the systemic and myocardial hemodynamics are shown in Table 1.

Above-threshold occlusion of the anterior descending branch of the left coronary artery caused a significant reduction of the blood flow in the ischemic zone of the myocardium (circular segment IV — apical zone): by 57 ± 13% in the subendocardial layer ($p < 0.05$) and by 33 ± 21% in the subepicardial layer (Table 2). Myocardial ischemia in all the rabbits was accompanied by elevation of the ST segment in precardial leads (Fig. 1). In response to above-threshold occlusion of the coronary artery BP fell significantly by 12 ± 3%, whereas the remaining parameters of the systemic hemodynamics were unchanged (Table 1). An increase of 39 ± 13% in the blood flow was observed in the right ventricle ($p < 0.05$).

Normalization of the ECG took place 8-15 min after the beginning of occlusion of the coronary artery. At the time when signs of ischemia disappeared on the ECG, BP remained 11 ± 3% lower ($p < 0.05$) than initially. A tendency for the blood flow to increase was observed in the zone of initial ischemia in both the subendocardial and subepicardial layers by 39 ± 18 and 32 ± 20% respectively.

The transient character of myocardial ischemia during partial occlusion of the coronary artery can be explained by two mechanisms: 1) by dilatation of the small coronary vessels in response to ischemic stimulation (exhaustion of the coronary reserve); 2) by opening of the collateral vessels.

Rabbits are animals in which the coronary collateral vessels are poorly developed [6], although there is evidence that even in rabbits collateral vessels may be functionally significant [7].

The maximal value of the myocardial collateral blood flow obtained in [7] was about 1 ml/(min·g), significantly lower than the myocardial blood flow at the time of normalization of the ECG in the ischemic zone, obtained in the present study (4.78 ml/min/g). It is therefore difficult to suggest what is the essential role of collateral vessels in the mechanism of abolition of myocardial ischemia during partial occlusion of the coronary artery. The first mechanism, connected with exhaustion of the coronary reserve, is evidently more important. Most likely under the conditions of the present experiments, when the resistance of the coronary vessels was increased against the background of immobilization stress (Table 1), partial stenosis of the coronary artery causes myocardial ischemia, while the coronary dilator reserve remains sufficiently high, until its gradual exhaustion leads to normalization of the myocardial blood flow. By the 18th day of development the number of CAE cells in this explanation is supported by data in the literature according to which, in the presence of low perfusion pressure associated with functionally significant ischemia the coronary reserve may be preserved [3] and adrenergic vasoconstrictor tone maintained [4]. The normalization time of the ECG evidently depends on the rate of vasodilatation in the ischemic zone and it can be used to assess the action of antianginal drugs on the circulation of the ischemic myocardium.

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MICROCIRCULATION AND BLOOD RHEOLOGY IN ARTERIAL AND VENOUS FORMS OF MESENTERIC VASCULAR OCCLUSION

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KEY WORDS: microcirculation; blood rheology; occlusion

The aim of this investigation was to determine the character of the vascular response and the time course of development of disturbances of the blood rheology in acute mesenteric vascular insufficiency, due specifically to occlusion of the cranial mesenteric artery (CMA) and vein (CMV).

EXPERIMENTAL METHOD

Two series of experiments were carried out on 56 mongrel dogs weighing 18-20 kg. The control group consisted of seven dogs, in which the effect of immobilization of the animals in the supine position, laparotomy, and barbiturate anesthesia on parameters of the microhemodynamics and blood rheology was studied. A model of the disease was created by ligation of CMA (series I) and CMV (series II). Blood sampling and biomicroscopy were carried out 1 and 3 h after creation of the model. The blood viscosity was studied on a "Rotovisco RV-100" rotary viscometer (Haake, West Germany), with a shear velocity of 1 sec^{-1}. The hematocrit index was determined with a "KIT" hematocrit centrifuge (USA). The microcirculation was studied by contact biomicroscopy on the LYUMAN K-1 microscope (Leningrad Optico-Mechanical Combine), followed by photographic recording and morphometry of the specimen material on a "Mikrofot" apparatus (magnification 100). The results were subjected to statistical analysis on the PDP 11/34 computer (DES, USA).

EXPERIMENTAL RESULTS

The results are evidence that 1 h after occlusion of CMA generalized spasm of the afferent vessels of the small intestine was observed; the diameter of the arterioles was reduced from 42.6 ± 3.11 to 22.97 ± 1.1 μ ($p < 0.1$) and of the capillaries from 14 ± 0.1 to 8.1 ± 0.2 μ ($p < 0.001$). The diameter of the venules was reduced from 59.22 ± 2.8 to 40.83 ± 3.52 μ ($p < 0.01$). The capillary bed showed no significant change.

A completely different picture was observed 1 h after occlusion of CMV. The diameter of the afferent and efferent vessels was sharply increased: of the arterioles from 44.9 ± 3.1 to 57.9 ± 1.4 μ ($p < 0.1$), of the precapillaries from 11.5 ± 0.2 to 17.6 ± 1.3 μ ($p < 0.01$), and of the venules from 58.0 ± 1.7 to 98.7 ± 3.2 μ ($p < 0.01$). As a result of this reaction, dilatation of the capillaries was observed.

Persistent but nonprogressive vasoconstriction continued 3 h after acute occlusion of CMA in all components of the circulatory bed. During acute occlusion of CMV, on the other

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