CORONARY BLOOD DRAINAGE VIA PARASINUS PATHWAYS INTO THE LEFT HEART (A POSSIBLE PATHOGENESIS OF ANGINA WITH NORMAL CORONARY BLOOD FLOW)

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Blood is drained from the myocardium through the coronary sinus, the anterior veins of the heart, and the veins of Vieussens and Thebesius.

Data on the quantity of blood drained from the myocardium along the veins of Vieussens and Thebesius are contradictory: from 0% [9] to 90% [12]. The results of morphological studies point to considerable histotopographic and quantitative variability of these vessels depending on the character of the pathological process in the heart, and also on sex and age [1, 2]. A large number (in some cases the majority) of orifices of these vessels has been noted in the left side of the heart [2]. The diameter of the vascular shunts opening into the left ventricle is known to be greater than the diameter of shunts draining blood into the right heart [11]. It has hitherto been accepted that drainage of blood along vessels opening into the left side of the heart is on a very small scale, not more than 10% [3, 6, 11]. However, there is evidence that the drainage along parasinus pathways into the left side of the heart may amount to 45.5% in cor pulmonale and 76% in rheumatic heart disease [4]. It can be accepted that the quantity of blood draining along these vessels may increase considerably in certain types of pathology.

The aim of this investigation was to study whether the volume of blood draining along the parasinus pathways can change.

EXPERIMENTAL METHOD

Experiments were carried out on 28 cats' hearts, isolated by Langendorff's method and perfused with donor's blood at 37°C by means of a resitograph pump.

TABLE 1. Increase in Volume Velocity of Blood Drainage from Right (ΔQ_{pa}) and Left (ΔQ_{lv}) Sides of the Heart with an Increase in Volume Velocity of Perfusion (ΔQ_a) of the Isolated Heart (M ± m)

Increase in blood flow, ml/min	I period	II period	III period	IV period	Significance of difference between means, P
	0–30 min (n=13)	30–90 min (n=9)	hypoxia (n=4)	ischemia (n=8)	
ΔQ_a	13,4±1,8	14,9±1,9	18,5±3,2	15,9±1,2	
ΔQ_{pa}	8,5±1,7	11,1±1,2	10,5±1,3	3,2±0,6	$P_{I, IV}$ <0,05 $P_{II, IV}$ <0,001 $P_{III, IV}$ <0,001
ΔQ_{lv}	7,1±1,5	4,0±1,0	8,2±2,0	10,4±0,9	$P_{II, IV}$ <0,001

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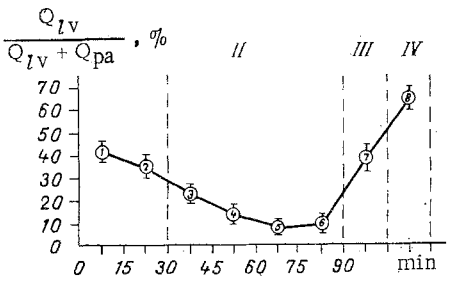

Fig. 1

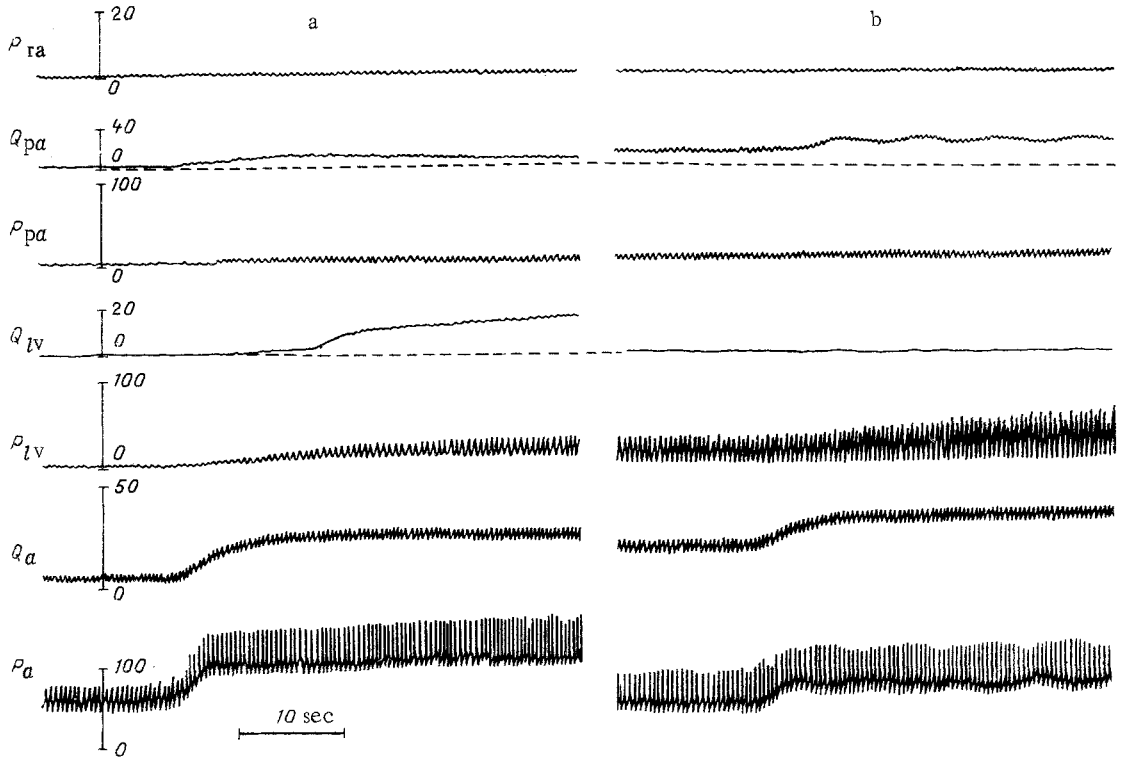

Fig. 2

Fig. 1. Changes in mean values (M ± m) of relative blood drainage from left chambers of heart (in % of total blood outflow) during periods I-IV of function of isolated heart. I, II) Perfusion with donor's arterial blood; III) hypoxia; IV) ischemia. Difference significant at $P < 0.01$ level between means 1-3, 1-4, 1-5, 1-6, 1-8, 2-5, 2-8, 3-8, 4-8, 5-7, 5-8, 6-8, and 7-8 and at $P < 0.05$ level between means 2-4, 2-6, and 4-7.

Fig. 2. Effect of increase in volume velocity of perfusion on blood drainage from right and left sides of isolated heart at 4th minute (a) and 36th minute (b) after beginning of perfusion. P_{ra}) Pressure in right atrium; Q_{pa}) blood drainage from right side of heart; P_{pa}) pressure in pulmonary artery; Q_{lv}) blood drainage from left side of heart; P_{lv}) pressure in left ventricle; Q_a) total volume of perfusion; P_a) perfusion pressure (pressure in mm Hg, blood flow in ml/min).

The animals were anesthetized with pentobarbital (30-40 mg/kg). The central end of the pulmonary artery was connected to a reservoir (placed a little below the level of the heart), into which blood drained from the right heart. A double-barreled catheter was inserted through the apex into the left ventricle and served to record pressure in the left ventricle and drainage of blood from the left heart simultaneously. Perfusion continued for 90-120 min. By means of electromagnetic flowmeter transducers the inflow of blood into the myocardium, outflow of blood from the right heart including drainage along the system of the coronary sinus, anterior veins, and veins of Vieussens and Thebesius, opening into the right chambers,

and outflow of blood from the left side of the heart (i.e., along vessels of Vieussens and Thebesius opening into the left side of the heart) were recorded. The pressure in the right atrium, pulmonary artery, left ventricle, and arch of the aorta (perfusion pressure) was recorded by means of electromanometers on a Mingograph-82 apparatus. Drainage of blood from the myocardium was studied with the heart functioning under different conditions: I) in the period of recovery of the heart from operative trauma and adaptation to conditions of extracardial denervation and modification of the intracardiac hemodynamics (0-30 min from the beginning of perfusion with arterial blood); II) during normalization of the work of the heart, characterized outwardly by regular cardiac rhythm and an increase in and stabilization of the force of the cardiac contractions (30-90 min after the beginning of perfusion); III) during perfusion of the heart with venous blood; and IV) during perfusion of the heart after total myocardial ischemia for 30 min. The results of 12 experiments in which the time course of changes in drainage of blood could be traced during the above period were analyzed. The results were subjected to statistical analysis by Student's t test.

EXPERIMENTAL RESULTS

Continuous recording of volumes of blood flowing into the right and left chambers of the heart revealed considerable reversible changes in the course of the experiment. The mean values of relative blood drainage from the left chambers of the isolated heart (in % of the total outflow) during the above-mentioned four periods are given in Fig. 1. Drainage of blood into the left heart began during the first minutes after the beginning of perfusion and remained at a high level (average 39%) for about 30 min. Minimal relative values of blood drainage into the left chambers (mean 10%) occurred during the period from 30 to 90 min, when the work of the heart was restored to normal (which does not contradict the generally accepted view that the relative volume of blood draining along the parasinus pathways into the left heart under conditions of the normally functioning heart is negligible). The relative blood drainage into the left chambers increased (on average to 39%) during hypoxia. Maximal relative values of drainage into the left chambers of the heart (up to 64%) were observed after total ischemia for 30 min.

This is in agreement with data obtained by workers [4] who found an increase in the relative importance of the parasinus pathways of the left side of the heart for blood drainage from the myocardium under pathological conditions.

In experiments on the same hearts the effect of an increase in perfusion volume on distribution of blood drainage into the right and left sides of the isolated heart was studied during the above-mentioned four periods. An increase in the perfusion volume led to a marked increase in blood drainage from the left chambers in period I (Fig. 2a) and also in periods III and IV, i.e., under conditions of hypoxia and ischemia, and caused a very small increase in blood drainage from the left chambers of the heart in period II, i.e., when function of the isolated heart was normal (Fig. 2b). The amount of drainage of blood into the left chambers is thus determined, not by the level of perfusion, but by the conditions of cardiac function (Table 1).

It can be tentatively suggested that under normal physiological conditions no significant drainage of blood takes place along the parasinus pathways into the left side of the heart. The large drainage into the left chambers obtained in periods I, III, and IV was accompanied by high levels of perfusion pressure, on average 166/100 mm Hg and, consequently, it could be due to the development of functional insufficiency of the aortic valves. However, the possibility cannot be ruled out that during these same periods there was also an increase in parasinus drainage into the left chambers.

Data in the literature presented below are evidence that in such cases attacks of angina may arise as a result of disproportionate shunting of coronary blood (bypassing the myocardial capillaries) along the veins of Vieussens and Thebesius.

Communication of coronary arteries and arterioles directly with the chambers of the heart was first demonstrated in [13]. The two types of vessels discovered by Wearn (arterio-sinusoidal and arterio-luminal) communicate with the chambers of the heart, bypassing the capillaries. Communication of the arterial division of the coronary system with the left chambers of the heart, into which up to two thirds of the blood entering the coronary artery may be discharged, has been demonstrated angiographically [6, 8]. Some workers regard this phenomenon as due to abnormal fistulas of the coronary arteries, whereas others link it with the system of veins of Vieussens and Thebesius [7]. The research by Hammond [10] showed that

the partial pressure of oxygen in blood flowing from the left ventricle of the isolated heart is always greater than in blood flowing from the right heart. The data given above suggest that coronary blood does not drain into the capillaries of the myocardium but is shunted along arterio-luminal and arterio-sinusoidal vessels into the left chambers of the heart. The present investigation showed that the magnitude of this shunt can change substantially within relatively short intervals of time. Drainage into the left chambers of the heart increases considerably under conditions of hypoxia and ischemia. It can therefore be considered that, in pathology of the heart accompanied by these conditions, the appearance of considerable shunting of coronary blood into the left chambers of the heart can aggravate the oxygen hunger of the myocardium and lead to the development of attacks of angina.

The results also indicate that it is impractical to assess the blood supply to the myocardium from the inflow of blood into the coronary arteries alone. Acute insufficiency of the myocardial blood supply may evidently arise in the presence of a normal, or even increased, blood flow in the coronary arteries, should a considerable flow of arterial blood along the shunts directly into the chambers of the heart appear.

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POSSIBLE CORRECTION OF BRAIN ENERGY METABOLISM IN NEUROSES BY NICOTINIC ACID DERIVATIVES

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Pharmacologic control of CNS functions in neuroses, permitting a systemic approach to their analysis, is important from both theoretical and practical points of view. One of the main manifestations of neurosis is a disturbance of energy metabolism and neurochemical processes that lie at the basis of mechanisms of psychological adaptation [2, 3]. Any unfavorable influence acting on the body automatically involves energy metabolism. In neurosis any extraordinary load, even of emotional character, which has a psychological basis somehow or other is managed through the state of the energy systems of the neuron [6, 8]. There is thus a definite need for the creation and pharmacologic study of new psychotropic drugs to control the course of nervous processes at the level of brain energy metabolism. Tranquilizers now available and widely used, especially benzodiazepine derivatives, despite their marked stress-protective effect, themselves inhibit brain energy metabolism [9, 12].

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