SIGNIFICANCE OF CHANGES IN VASCULAR TONUS IN THE DEVELOPMENT OF HEMODYNAMIC DISTURBANCES IN EXPERIMENTAL MYOCARDIAL INFARCT

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A disruption of the contractile function of the myocardium and a drop in arterial pressure are severe sequelae of acute myocardial infarct.

There is no agreement among researchers on whether acute myocardial insufficiency [2, 7, 12, 14, 22, 23] or acute vascular insufficiency [21] is the principal factor in the development of hemodynamic disturbances in myocardial infarct. The lack of a strict concept to explain the pathogenesis of cardiovascular disturbances in myocardial infarct hinders the development of effective methods for treating this ailment. Investigation of hemodynamics as part of the symptomatology of myocardial infarct, especially during the first few minutes and hours after the development of the acute disturbance of coronary circulation, is still not possible. The results of experimental investigations are of material importance in solving the disputed problems of the pathogenesis of myocardial infarct.

Our work was intended as a study of certain problems of the pathogenesis of cardiovascular disturbances in myocardial infarct on experimental models of acute coronary insufficiency.

EXPERIMENTAL METHOD

In chronic experiments of 23 dogs and 8 cats, using the diffusion of T-1824 dye [3, 9, 10, 17, 19], we determined the minute and stroke volumes of the heart, the circulating-blood volume, the blood-flow time, and the total circulation time. We measured the mean arterial pressure and calculated the total peripheral resistance of the blood vessels. We simultaneously recorded an EKG with the standard, amplified extremital, and amplified thoracic leads, by Wilson's method, and a velocity ballisto-cardiogram.

Since study of the hemodynamic shifts which develop when the lumen of the coronary artery is occluded in acute experiments with the thoracic cavity open and the animal given artificial respiration against a background of severe traumatization cannot be considered satisfactory, we induced an experimental myocardial infarct by constricting the descending branch of the left coronary artery, at the boundary between its upper and middle thirds, with an ordinary slip noose 7-10 days before the experiment. The ligature was tightened with the thoracic cavity closed, under morphine-chloralose anesthesia.

In experiments on 38 cats we used resistography [11] to investigate the changes in peripheral resistance to blood flow after occlusion of the lumen of the coronary artery. In this series of experiments we recorded the arterial pressure, respiration, and the perfusion pressure in the common carotid artery and the arteries of the extremities and mesentery. The experimental myocardial infarct was induced by the same method as in the dogs.

EXPERIMENTAL RESULTS

The experiments conducted on the dogs showed that symptoms of disruption of the contractile function of the

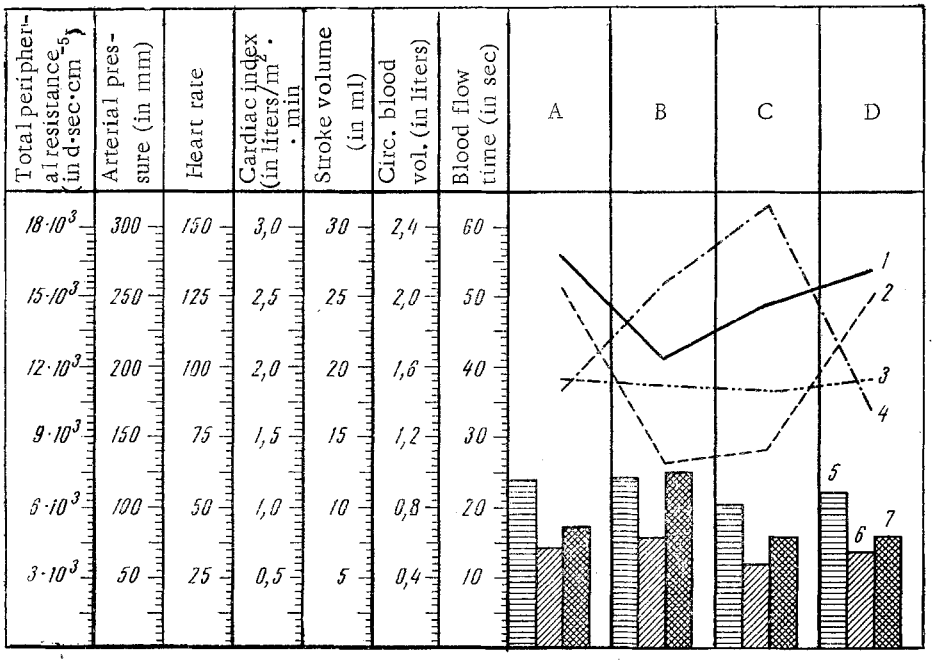

Fig. 1. Changes in hemodynamic indices during experimental disruption of coronary circulation (averaged data). 1) Cardiac index (in liters/$m^2 \cdot$ min); 2) stroke volume (in ml); 3) circulating-blood volume (in liters); 4) heart rate; 5) arterial pressure (in mm); 6) blood-flow time (in sec); 7) total peripheral resistance (in $d \cdot sec \cdot cm^{-5}$). A) Initial data; B) 30 min after ligation of the coronary artery; C) after 24 h; D) after 15 days.

myocardium are noted within the first few minutes after the lumen of the coronary artery is occluded; these take the form of disturbances in the ballistocardiogram (fused HJ waves and a decrease in the amplitude of the systolic waves), a decrease in the minute and stroke volumes of the heart, and an increase in the blood-flow time and the total circulation time. In the majority of the experiments the mean arterial pressure decreased after obstruction of the coronary artery and then, over a period of several minutes, reverted to its initial level or even rose somewhat above it. Figure 1 shows the changes in hemodynamic indices at various times during the development of experimental myocardial infarct.

The increase in total peripheral resistance which we observed in the majority of the experimental animals during the acute stage of experimental myocardial infarct is apparently one of the compensatory reactions most important for the outcome of the pathological process. The extent to which various branches of the vascular system participate in the changes in total peripheral resistance may differ. We set ourselves the task of determining the significance of changes in the tonus of various vascular regions in producing the changes in total peripheral resistance.

In the vascular regions which we investigated the peripheral resistance to blood flow first rose briefly (2-5 sec) and then trended in different directions. In a substantial number of the experiments the peripheral resistance rose in the extremital vessels and dropped markedly in the mesenteric and carotid arteries. Some of these animals died exhibiting a progressive drop in resistance in the vessels of the internal organs and head and a decrease in total arterial pressure (Fig. 2).

In other animals there was a marked increase in vascular resistance in the basin of the mesenteric artery in addition to a more or less substantial increase in peripheral resistance in the extremital vessels; the peripheral resistance in the basin of the carotid artery decreased substantially. After a brief drop when the lumen of the coronary artery was occluded the arterial pressure gradually reverted to its initial level or remained somewhat below it (Fig. 3). These animals survived despite marked disruptions of cardiac activity.

It must be noted that clinicians have also pointed out that there is a wide-spread spasm of the peripheral vessels in acute myocardial infarct [3, 8].

Of the experimental investigations we must mention the work of Levy and Frankel [18], who studied the resis-

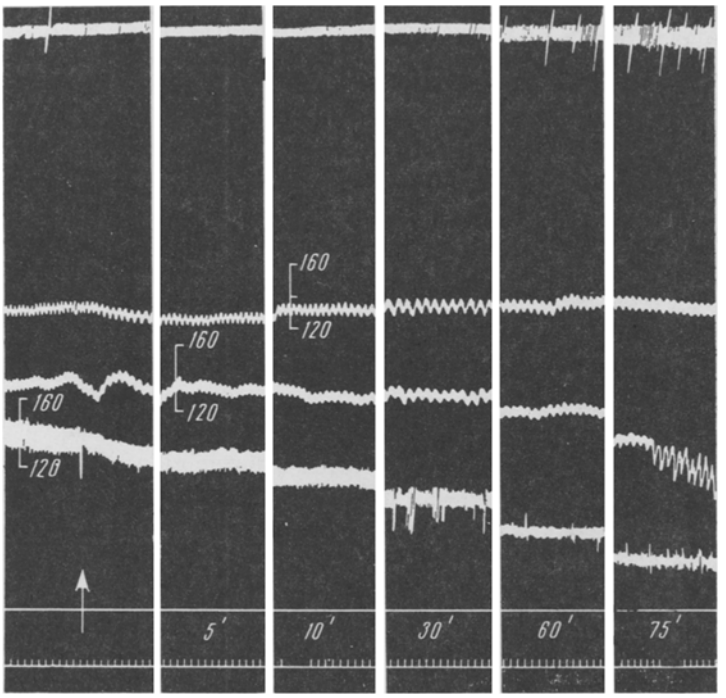

Fig. 2. Changes in arterial pressure and vascular tonus in cat No. 30 during experimental myocardial infarct. The curves represent (from top to bottom): respiration, a resistogram of the femoral artery, a resistogram of the mesenteric artery, and arterial pressure before and 5, 10, 30, 60, and 75 min after ligation of the coronary artery. The moment of ligation is indicated by the arrow. The time marker is 2 sec.

tance to blood flow in the extremities of dogs during experimental myocardial infarct and noted that it exhibits a clear and regular increase.

In comparison with the data obtained in studying general hemodynamics in experimental myocardial infarct the resistographic investigations which we conducted show that after occlusion of the lumen of the coronary artery there is an increase in total peripheral resistance conjoined with changes in tonus trending in different directions in different vascular regions, in addition to depression of the contractile function of the myocardium. Maintenance of the resistance to blood flow at its initial level or even an increase in this resistance in the extremital vessels alone does not ensure that the arterial pressure will be kept at a sufficiently high level. This level is decisively dependent on the tonic state of the vessels of the internal organs.

It is probable that the sharp drop in stroke and minute volumes and the associated decrease in arterial pressure which occur when there is an acute disturbance of coronary circulation actuate certain compensatory mechanisms. As a result, the total peripheral resistance increases and the arterial pressure may not only regain its initial level, but may even exceed it. This compensation is limited primarily by the extent to which the contractile ability of the myocardium is disrupted. An increase in total peripheral resistance may apparently compensate for the drop in arterial pressure which occurs as a result of depression of cardiac activity for a limited time only, but this time is frequently sufficient for compensation to develop for the disruption of myocardial contractile functioning in the ischemic and necrotic zone. If the compensatory mechanisms which act to maintain hemodynamics at a level sufficient for the functioning of the vital organs become inadequate, there arise disruptions of myocardial metabolism nervous regulation of circulation, and vascular permeability and other disturbances which in toto lead to the development of cardiovascular collapse.

In the light of the experimentally obtained data we must call attention to the following fact. While drugs intended to intensify cardiac activity during cardiovascular collapse resulting from an acute disruption of coronary

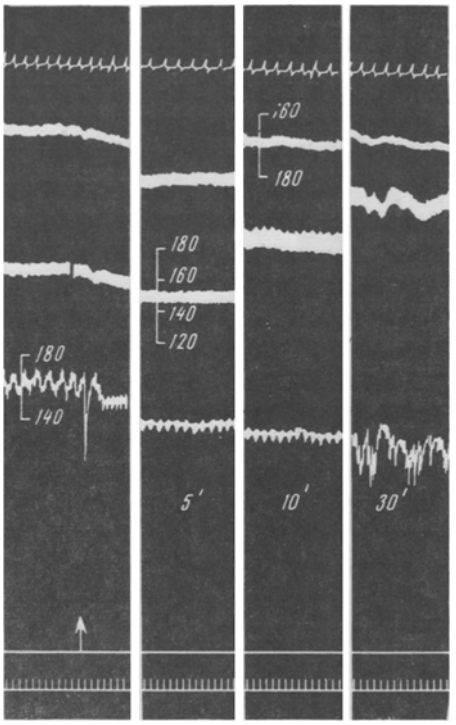

Fig. 3. Changes in arterial pressure and vascular tonus in cat No. 5 during experimental myocardial infarct. The curves represent (from top to bottom): respiration, a resistogram of the femoral artery, a resistogram of the mesenteric artery, and arterial pressure before and 5, 10, and 30 min after ligation of the coronary artery. The moment of ligation is indicated by the arrow. The time marker is 2 sec.

circulation do not usually have a favorable effect, administration of norepinephrine, mesaton, and other drugs which promote an increase in general and peripheral resistance substantially reduces mortality in acute myocardial infarct [2, 16].

The decrease which we noted in the vascular tonus of the basin of the common and internal carotid arteries is of special interest. A number of authors describe a so-called cardiocerebral syndrome in acute myocardial infarct. The pathogenesis of this syndrome is still a matter of dispute. A number of researchers [1, 5] hold that the cerebral symptoms present in acute myocardial infarct are caused by a reflex spasm of the cerebral vessels. Other authors [13, 20] maintain that the temporary cerebral ischemia and hypoxia result from the severe drop in arterial pressure which occurs during the acute period of myocardial infarct. Corday, Rothenberg, and Putnam [15] have introduced the term "acute cerebral vascular insufficiency." In their opinion, this insufficiency is caused by local cerebral hypotension. M. Yu. Melikova [6] studied sections taken from 130 patients who died during the acute period of myocardial infarct, exhibiting the conjoint cerebral symptoms, and noted substantial changes in tonus, paretic dilation, stasis, and a disruption of vascular permeability in the cerebral vessels. The investigations which we conducted show that the peripheral resistance of the vessels supplying the brain is reduced when there is an acute disturbance of coronary circulation. Cerebral hypotension conjoined with arterial hypotonia is apparently an important link in the mechanism by which the cardiocerebral syndrome develops.

SUMMARY

In experiments on 23 dogs and 46 cats changes in hemodynamics were studied under conditions of experimental myocardial infarction. The finding was that there was a reduction in the minute and stroke cardiac volume, and an increase in the blood flow circulation general time. At the early periods of experimental myocardial infarction peripheral blood vessel resistance was increased.

Arterial pressure changes were determined by the state of the vascular tone of the internal organs. A reduction in the tone of cerebral vessels accompanying experimental myocardial infarction was likewise revealed. The data obtained have been offered for discussion.

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