THE LOCAL REFLEX COMPONENT IN THE CARDIAC RESPONSE TO RAISED INTRAPULMONARY PRESSURE AND TO INCREASED PRESSURE IN THE VENA CAVA

O. M. Gal'perin and A. I. Briskin

Laboratory of Circulation and Respiration (Head – Prof. G. P. Konradi) AN SSSR
Institute of Physiology (Dir.– Academician K. M. Bykov) and Laboratory of
Pharmacology (Head– Candidate of Biological Sciences A. I. Briskin)
Institute of Experimental Biology and Medicine (Dir.– Prof. E. N. Meshalkin)
Siberian Division, AN SSSR
(Presented by Academician V. N. Chernigovskii)
Translated from Byulleten' Eksperimental'noi Biologii i Meditsiny, Vol. 50 No. 12,
pp. 11-14, December, 1960
Original article submitted December 29, 1959

Besides the central nervous system, the local viscero-visceral reflexes also play an important part in exerting control over a number of organs. Little work has been done until now to determine the importance of such reflexes in the control of cardiac activity.

In a heart-lung preparation, cardiac contractions increase as described by "Starling's Law" [5] when pressure in the vena cava is raised, and this effect results from the stretching of the cardiac muscle fibers due to the increased venous return into the right auricle during diastole. The marked reduction in cardiac output caused by increased intrapulmonary pressure is due to the increased resistance of the vessels of the lesser circulation.

However, there have been reports that the above explanation is incomplete. V. P. Demikhov [1] has pointed out that the small increase in pressure in the vena cava which is observed to induce an increase in cardiac contractions could not cause an appreciable mechanical extension of the thick muscle walls of the ventricles. G. P. Konradi [3] has quoted the experiments performed in his laboratory by A. A. Morozov, in which Ringer's solution containing novocaine passed through the heart eliminated the increase in systolic volume following increased venous pressure. The response to the injection of adrenaline was still maintained, indicating that the myocardium itself was not paralyzed by the novocaine. It was therefore proposed that the increased cardiac contractions following increased pressure in the vena cava must be brought about through nervous structures in the heart.

Essentially, on such a view, local reflexes would be involved in bringing about the response to increased pressure in the veins and distension of the auricular fibers, as described in Starling's Law. As far as the depression in the cardiac activity through increased pulmonary pressure is concerned, the reaction may be modified by a number of drugs; it would appear therefore that the phenomenon cannot be explained in terms of the increased resistance of the lesser circulation alone.

The object of the present investigation was to determine the part played in these reactions by central reflexes.

V. V. Zakusov and his co-workers [2] have shown that besides blocking transmission through sympathetic and parasympathetic ganglia, ganglion-blocking agents also depress viscero-visceral reflexes to a considerable extent. To depress the local reflex component to increased venous and pulmonary pressures we therefore used 0.1-2 mg per kg body weight of the ganglion-blocking agent arphonade.

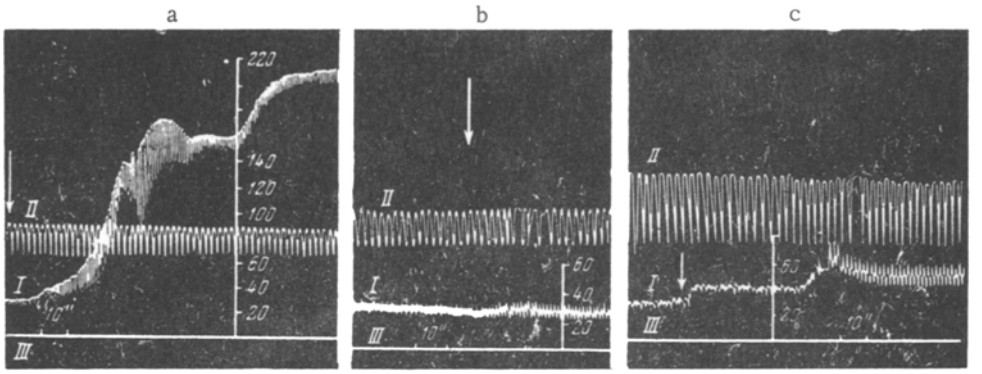

Fig. 1. Arterial pressure changes in a heart-lung preparation in response to the injection of 2 ml per kg of blood through a catheter into the right auricle (moment of injection shown by arrow). a) Initial response; b) after giving 1 mg per kg arphonade; c) after giving 5 mg per kg cysteine; I) blood pressure; II) intrabronchial pressure; III) zero blood pressure line. Experiment No. 28, August 23, 1959; weight of dog 10.5 kg.

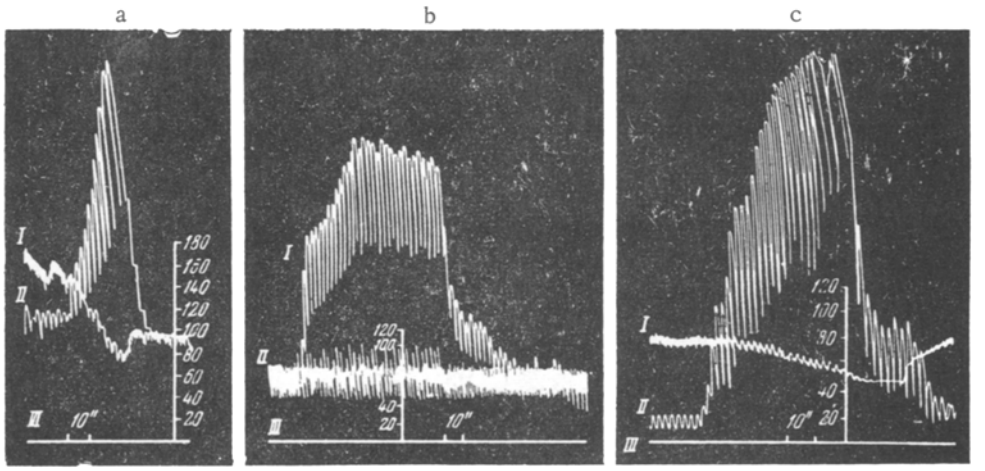

Fig. 2. Arterial pressure changes in a heart-lung preparation in response to increased intrapulmonary pressure. a) Initial response; b) after injecting 1 mg per kg arphonade; c) after injecting 5 mg per kg cysteine. Curves as in Fig. 1. Experiment No. 14, March 21, 1959; weight of dog 6.5 kg.

METHOD

A heart-lung preparation was made under morphine-thiopental anesthesia using the modification described by Yu. M. Gal'perin. A cannula was introduced into the subclavian artery, catheters were inserted into the azygous vein, the innominate artery and into the aorta (below the origin of the subclavian artery), and ligatures were applied. The cannula in the subclavian artery was connected to a pressure vessel at a height of 120 cm above the operating table. After withdrawing blood equal to 1.5-2% of the body weight, the ligatures were tightened, and owing to the cardiac contractions blood continued to flow from the left ventricle into the pressure vessel. After 5-8 min., when impulses from the central nervous system to the heart had been cut off, spontaneous contractions were produced which could be recognized from the nature of the blood pressure curve recorded by a mercury manometer, connected to the subclavian artery. When the cardiac contractions had become fairly constant, the pressure vessel was disconnected, and the following operations carried out: 1) a standard amount of blood (2 ml per kg body weight) was introduced into the right auricle through the catheter previously connected to the azygous vein; 2) the intrabronchial pressure was rapidly raised to 250-300 mm of water. The responses were recorded, and then the same operations were repeated after injecting 0.1-2 mg per kg of arphonade. When, during the experiment, the arterial pressure fell the pressure was connected to the preparation for 30 sec.; as a rule there was then

a considerable increase in the strength of the cardiac contractions and in arterial pressure. We performed a total of 12 experiments on heart-lung preparations of dogs weighing 6.5 - 22 kg.

RESULTS

The initial responses to the introduction of 2 ml per kg of blood into the right auricle and to increasing the pulmonary pressure to 200-300 mm Hg were all of the same type, and varied only in strength (Figs. 1a and 2a).

The introduction of up to 10 mg per kg body weight of arphonade into the coronary circulation caused no impairment of cardiac activity. The contractions were slightly increased and the frequency remained unchanged.

After injecting arphonade, the heart consistently changes its response to the measures applied. The reaction to the infusion of 2 mg per kg weight of blood into the right auricle was greatly reduced and delayed. The blood pressure showed a very slight rise, or else was unchanged, and in four of the 12 experiments it was actually reduced. As a rule there was a greater range of arterial pressure variation, which, however, did not occur for 8-15 sec. after the blood had been given (Fig. 1b), whereas before arphonade was injected the effect occurred within 1-2 sec.

An increase of intrapulmonary pressure after the infusion of arphonade caused some change in the nature of the recorded cardiac contractions; however, the blood pressure remained at the previous level, or was even somewhat increased (Fig. 2b).

Kh. S. Koshtoyants and his co-workers [4] showed that sulfhydryl groups play an active part in nervous excitation in general and in the transmission of nervous excitation in ganglia in particular; in six experiments therefore, after giving arphonade, we injected 5 - 10 mg per kg of cysteine in order that this sulfhydryl-group donor should come in contact with local reflex arc. After giving cysteine, the reaction to raised intrapulmonary pressure was approximately the same as it was initially (Fig. 2c); only in certain cases a greater and more prolonged increase in intrapulmonary pressure than had been required previously was needed to cause a drop in arterial pressure. The response to infusing blood after giving cysteine never reached the original intensity; however, it was greater than the response which occurred after arphonade had been given (Fig. 1c). Then the change in cardiac activity in response to an increase in the pressure in the vena cava occurred immediately after introducing the blood into the right auricle.

The cardiac response induced by arphonade is probably not due to any direct action on the coronary vessels, because no fall in coronary arterial pressure occurred after it had been injected. Further, the fact that its effects could be reduced or eliminated by means of cysteine also shows that arphonade affects the nervous structures of the ganglion directly.

The results of the experiments indicate that drugs which cause a change of conductivity in local intracardiac and cardiopulmonary reflexes have a definite influence on the responses induced by increase of intrapulmonary pressure and pressure in the vena cava. It would therefore appear that local reflex action plays an important part in the response described by Starling's Law, and in the response to increased pulmonary pressure.

SUMMARY

Experiments were performed on canine heart-lung preparations. Injections were given into the coronary circulation of 0.1-2 mg/kg body weight of arphonade, a ganglion-blocking agent which depresses local viscero-visceral reflexes; it was found that cardiac reactions to increased blood pressure in the vena cava (Starling's Law) and to a rise of intrapulmonary pressure were depressed. Injecting 5 - 10 mg/kg body weight of cysteine, which is a sulfhydryl-group donor partially restored the initial reactions. The results obtained indicate that local reflexes play an important part in the reactions described.

LITERATURE CITED

1. V. P. Demikhov, Byull. Eksp. Biol. Med. 29, 5, 397 (1950).
2. V. V. Zakusov and O. V. Ul'yanova, Farmakol. i Toksikol. 21, 2, 3, (1958).
3. G. P. Konradi, in: Textbook of Physiology. Edited by K. M. Bykov [in Russian] (Moscow, 1955), p. 114.
4. Kh. S. Koshtoyants, Protein Substances, Metabolism, and Nervous Regulations [in Russian] (Moscow, 1951).
5. E. H. Starling, Das Gesetz der Herzarbeit (Bern-Leipzig, 1920).