THE INFLUENCE OF THE CHEMORECEPTORS OF THE SINOCAROTID REGION ON THE CORONARY CIRCULATION

G. N. Aronova

Laboratory of the Physiology and Pathology of Respiration and Circulation (Head – Corresponding Member AMN SSSR, Professor M. E. Marshak) Institute of Normal and Pathological Physiology (Director – Active Member AMN SSSR V. V. Parin) AMN SSSR, Moscow Presented by Active Member AMN SSSR V. V. Parin

Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 53, No. 1, pp. 3-6, January, 1962
Original article submitted February 25, 1961

In recent years reports have appeared in physiological journals concerning the part played in circulatory regulation by the reflexogenous zones [12]. In particular it has been established that the chemoreceptors of the sinocarotid region exert a vasoconstrictor influence on the intestine, limbs, submaxillary glands [9, 10], the lesser circulation [11], and the brain [4].

It remains to find whether these receptors exert any influence on the tone of the cardiac vessels.

The object of the present investigation has been to determine the role of the chemoreceptors of the sinocarotid zone in regulating the tone of the coronary vessels.

METHOD

Experiments under morphine-urethan anesthesia were carried out on dogs weighing 15 - 23 kg. Several measures were taken to eliminate the effect on the coronary vessels of the change in the flow to them due to variation of the pressure in the aorta, stimulation of the baroreceptors of the sinocarotid zone, etc.

A thermoelectric method was used to record changes in the minute volume in the circumflex branch of the left coronary artery, and the pressure in the femoral artery was also registered [1]. The isolated carotid sinus was bathed with blood from a donor dog which was made to inhale periodically a mixture containing 6% oxygen and 94% nitrogen. In some of the experiments, hypoxia of the donor caused an increase of arterial pressure which could act as a stimulus to the baroreceptors of the isolated sinus of the recipient. To eliminate this effect, in the path of the bloodflow from the sinus we inserted a three-way tap, and when the pressure rose, part of the blood was led off into the central end of the femoral vein of the donor through a tube regulated by a clamp.

In other experiments, to determine changes of coronary tone, we used the method of resistography [7, 8]. A polyethylene cannula was inserted into the descending branch of the left coronary artery, and by means of a perfusion pump, autoperfusion of blood from the brachial artery was established, and supplied a constant amount of blood independent of variations of arterial pressure. We recorded the pressure in the femoral artery, and the perfusion pressure in the coronary artery, which was an index of the tone of this vessel.

The chemoreceptors of the carotid sinus were stimulated by venous blood from the same dog, by a modification of the method of I. and M. Daly [11]. Into the cavity of the right auricle we inserted a polyethylene catheter which connected the three-way tap with the isolated carotid sinus. By means of a second channel of the perfusion pump, we produced a pulsed supply of a constant amount of arterial or venous blood from the right auricle, to stimulate the chemoreceptors. The pressure in the sinus remained practically constant when the changeover was made in the perfusion from arterial to venous blood. Blood from the sinus was taken through the external carotid artery to the central end of the femoral vein, and on the way the resistance was regulated so as to enable a constant intrasinus pressure equal to the systemic arterial pressure to be maintained.

By means of the perfusion pump, blood was supplied to the descending branch of the left coronary artery of the recipient from the donor dog, and the perfusion pressure in it was recorded as well as the arterial pressure in the femoral artery. The reverse flow of blood from the recipient to the donor was from the peripheral end of the femoral vein to the central end of the donor femoral vein, and the flow rate was regulated by a clamp on the tube con-

necting these two vessels. The chemoreceptors were stimulated by causing the recipient dog to breathe a mixture of 6% oxygen and 94% nitrogen.

The feature which distinguishes this procedure from the other two methods is that when air with a reduced oxygen content is breathed, not only are the chemoreceptors of the sinocarotid zone stimulated but so also are those of other receptor zones. However, during the hypoxia, the coronary artery was supplied with blood from a donor dog having normal oxygen content, and therefore the change in the perfusion pressure could be caused only by a reflex influence originating in the chemoreceptors of the vascular system.

The experiments were carried out on 18 dogs, in each of which the chemoreceptors were stimulated several times. For the perfusion of an artery we used heparin, and artificial respiration of the room air was maintained.

RESULTS

The experiments carried out by three variations of the method showed that when the chemoreceptors of the sinocarotid zone are adequately stimulated by blood having a reduced oxygen content there was no appreciable change in the tone of coronary vessels.

In the great majority of cases, when the isolated carotid sinus was stimulated by venous blood or by hypoxic blood from the donor, either there was no change in the level of the perfusion pressure (or, in another set of experiments, of the minute volume of the coronary flow), or else there was a very small restriction of the coronary vessels.

Figure 1 shows the result of one experiment in which the chemoreceptors were stimulated by perfusion of the isolated sinus of a dog with its own blood. From Fig. 1 it can be seen that in the perfusion when the changeover was made from arterial to venous blood, there was no change in the perfusion pressure of the cardiac vessels. Change in pulse frequency did not occur, and all that was observed was a very small change of arterial pressure. As a control over these experiments, which were performed with an opened thoracic cavity and artificial respiration, we carried out others with normal respiration; here it was shown that when the isolated coronary sinus was perfused with venous blood there was a marked increase in the frequency and amplitude of the respiratory movements. Therefore, perfusion with venous blood undoubtedly causes stimulation of the chemoreceptors. In some cases, during perfusion with venous blood, a very small contraction of the coronary vessels was observed.

In a third arrangement of the experiment, when the dog breathed air containing a reduced oxygen content and while the coronary vessels were still perfused with blood from the donor having a normal oxygen content it was found that as a rule the coronary vessels contracted very weakly, or not at all. Only in one experiment of this series (Fig. 2) was there a more marked increase of the perfusion pressure; a strong contraction of the vessels occurred for several minutes after hypoxia had ceased.

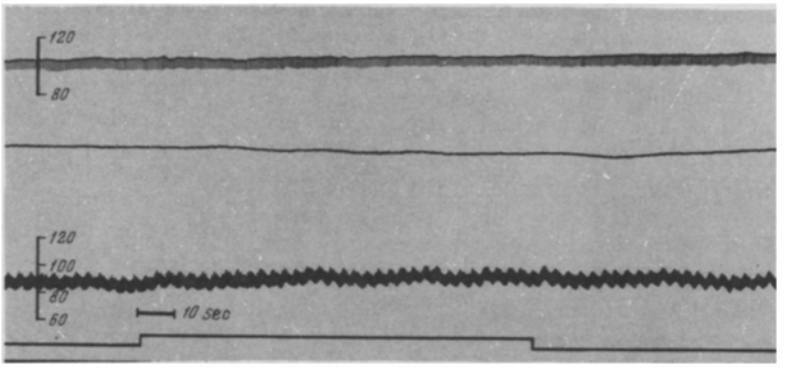

Fig. 1. Records of the perfusion pressure in the coronary vessels during stimulation of the chemoreceptors of the sinocarotid region. Curves, from above downwards: perfusion pressure in the descending branch of the left coronary artery; perfusion pressure in the isolated carotid sinus; pressure in the femoral artery; marker indicating time of perfusion of the carotid sinus with venous blood.

In considering these results it is important to remember that in the third arrangement of the experiment, the chemoreceptors of all the reflexogenous zones were stimulated, and therefore a more marked reaction would be expected than in experiments in which only the carotid sinus was perfused, though then as a rule the reaction was insignificant or absent.

It has long been known [13 and others], that a generalized hypoxia causes a dilatation of the coronary vessels. This action is due to hypoxia of the myocardium, as may easily be shown by perfusion of the coronary artery with hypoxic blood.

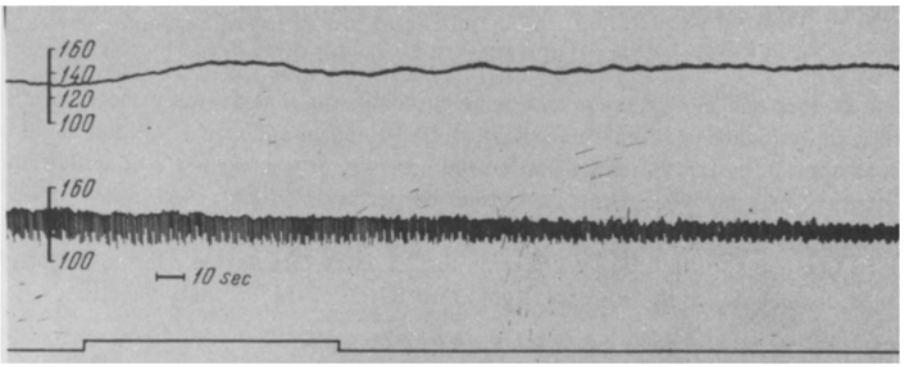

Fig. 2. Change of perfusion pressure in the coronary artery during generalized hypoxia (perfusion from donor). Curves, from above downwards: perfusion pressure in the descending branch of the left coronary artery; pressure in the femoral artery; marker indicating time of respiration of air containing a reduced amount of oxygen.

Figure 3 shows results of an experiment in which a perfusion pump was used to supply blood to the coronary artery through a cannula from a donor dog breathing air with a reduced oxygen content. It can be seen that there was then a marked fall of perfusion pressure but no change in the cardiac activity of the recipient, which indicates a dilatation of the vessels of the myocardium as a result of its hypoxia.

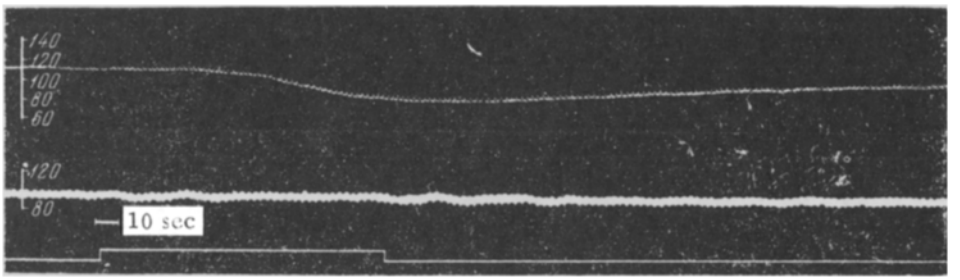

Fig. 3. The change of the perfusion pressure in the coronary artery when perfused with hypoxic blood from a donor. Curves, from above downwards: perfusion pressure in the descending branch of the left coronary artery; pressure in the femoral artery; marker showing perfusion with hypoxic blood.

If, however, during general hypoxia, the coronary vessels are perfused with blood with normal oxygen content, as was done in the third set of experiments, then there is no dilatation; sometimes the coronary vessels may even contract. There is every reason to suppose that this constriction is brought about by reflex influences from chemoreceptor zones, especially because the effect is observed when the isolated sinus is perfused with blood having a reduced oxygen content.

The tone of the coronary vessels is regulated by the combined influences of nervous, humoral, and mechanical factors. The metabolic processes of the myocardium bring about the dilatation of its vessels, and owing to the constant work of the heart local vasodilatory effects preponderate over reflex vasoconstrictor influences. In this way we can see why pressor actions which bring about a constriction of the peripheral vessels have no influence on coronary tone [6].

Under physiological conditions it is very seldom that constriction of the coronary vessels in normal animals can be observed. The effect was noted in certain experiments, and only when stimulating certain viscera—the gall bladder, stomach, or renal pelvis [2, 14]. As investigations in our laboratory have shown, in dogs with chronically implanted thermoelectrodes, the blood supply to the heart increases in response to a wide range of stimuli. Only under the influence of exceptionally strong auditory or painful stimuli was it possible to observe any constriction of the coronary vessels, and it occurred in only some of the dogs [3, 5]. It is on account of this feature of the cardiac circulation, which is due to the constant output of the heart and the strong metabolic processes, that we observed only a negligible influence to be exerted on the coronary vessels by the chemoreceptors of the sinocarotid zone.

SUMMARY

Experiments were carried out on dogs under morphine-urethan anesthesia; the minute volume of the coronary circulation was determined by means of thermoelectric recordings, and in addition a method based on a change of electrical resistance was applied in experiments in which the coronary artery was perfused with blood at a constant rate. The chemoreceptors of one dog were stimulated either by perfusion with its own venous blood through the isolated carotid sinus, or by perfusion with the blood of a hypoxic donor dog. It was found that adequate stimulation of the chemoreceptors caused but an insignificant effect on the coronary circulation. In the majority of experiments, either the tone remained unchanged, or there was a slight constriction of the coronary vessels.

LITERATURE CITED

1. Aronova G. N. Fiziol. zhurn. SSSR, 1956, No. 10, p. 898.
2. Aronova G. N. Transactions of the Institute of Clinical and Experimental Cardiology, Georgian AN SSR, Tbilisi, 1958, vol. 5, p. 423.
3. Aronova G. N. and Maeva T. A. Fiziol. zhurn. SSSR, 1958, No. 10, p. 952.
4. Blinova A. M. and Ryzhova N. M. Abstracts of the Conference "The Physiology and Pathology of the Circulation." Kiev, 1959, p. 19.
5. Marshak M. E. and Aronova G. N. Byull. éksper. biol. i med., 1957, Appendix to No. 1, p. 3.
6. Marshak M. E. Vestn. AMN SSSR, 1959, No. 9, p. 36.
7. Khayutin V. M. Fiziol. zhurn. SSSR, 1958, No. 7, p. 645.
8. Khayutin V. M., Donchakov V. M. and Tsaturov V. L. Byull. éksper. biol. i med., 1958, No. 2, p. 117.
9. Bernthal T. and Schwind F., Am. J. Physiol., 1945, v. 143, p. 361.
10. Bernthal T., Motley H. E., Schwind F. J. et al. Am. J. Physiol., 1945, v. 143, p. 220.
11. Daly I. de B. and Daly M. de B. J. Physiol. (Lond.), 1957, v. 137, p. 436.
12. Heymans C. and Neil E., Reflexogenic Areas of Cardiovascular System. London, 1958.
13. Hilton R. and Eichholtz, J. Physiol., 1925, v. 61, p. 615.
14. Hinrichsen J. and Ivy A. C., Arch. Intern. Med., 1933, v. 51, p. 932.
