STUDY OF CORONARY BLOOD FLOW IN UNANESTHETIZED DOGS

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Data relating to the physiology and pathology of the circulation of the heart have chiefly been derived from short experiments on animals. Essex alone was able, using a thermoelectric method, to observe changes in the rate of flow of blood in the coronary arteries of dogs, kept under natural conditions over periods of from some days up to a maximum of two weeks after the operation [2].

We have recorded the dynamics of changes in flow-rate in a branch of the coronary artery of unanesthetized dogs in response to various stimuli, over a period of six weeks after the operation.

EXPERIMENTAL METHODS

Noyens' thermoelectric method [3] was applied to the study of variations in the rate of flow of blood in intact vessels, modifying the thermoelectrodes in order to apply them to the conditions of a long experiment. The thermoelectrode used for implantation into the coronary vessels differed from that described by Noyens for short experiments, as described by M. E. Marshak and M. M. Voll [1] in its smaller dimensions (5-6 mm wide) and in its low weight (about 1.3 g). A nickeline strip was used for warming the junction of the thermocouple. We endeavored to exclude constriction of the artery, and to ensure prolonged functioning of the thermoelectrode. The thermoelectrode was applied to an encircling branch of the left coronary artery of the experimental animals. The operational technique differed from that used by Essex, who sutured the leads from the thermoelectrode to the myocardium, which is not without effect on the functioning of the heart and on its blood supply. We sutured the leads from the electrode to the inner surface of the thoracic wall. The terminals of the leads were exteriorized at the neck, where they were connected during experiments with leads from the galvanometer and accumulator.

EXPERIMENTAL RESULTS

Changes characteristic of disturbance of coronary circulation were seen in the T wave of the electrocardiogram during the first few days after the operation. Full restoration of coronary circulation took place on the 7th day, as seen from the electrocardiogram.

Only insignificant fluctuations in the rate of flow of blood in the coronary artery of dogs standing at rest on the bench were observed. Feeding (milk or meat) caused a well-defined rise in the flow-rate, persisting for several minutes after completion of feeding as is shown by Figure 1.

Inhalation of air of a raised CO_2 content (about 2-3%) raised the rate of flow in the cornary artery, and substitution of ordinary air led to a slow return to the initial value.

As for short experiments, distention of the rectum of unanesthetized dogs for 1 minute caused a marked increase in the blood supply to the heart. As appears from Figure 1, b, the heightened flow rate persisted for 4 minutes after distention had been discontinued, and return to the initial value took place only very slowly.

The effect on the coronary flow rate of static loading of the dogs (a saddle supporting a weight of 5-8 kg was fastened to their back) was also investigated. A well-defined rise in the rate of flow was registered immediately after loading, and the raised level persisted as long as the load remained, and for some minutes after its removal. Restoration of the normal rhythm and depth of respiration took place much sooner than restoration of the initial flow rate. Repetition of the experiment, with the same load, led to a smaller elevation of flow-rate; this can be regarded as a training effect.

Figure 1,c shows the effect on the rate of flow in the coronary artery of an aggressive stimulus, in this case the appearance of a cat. As is seen from the curve, the flow-rate rose gradually to a maximum when the dog was most excited, and displayed abrupt fluctuations, with heightened respiration.

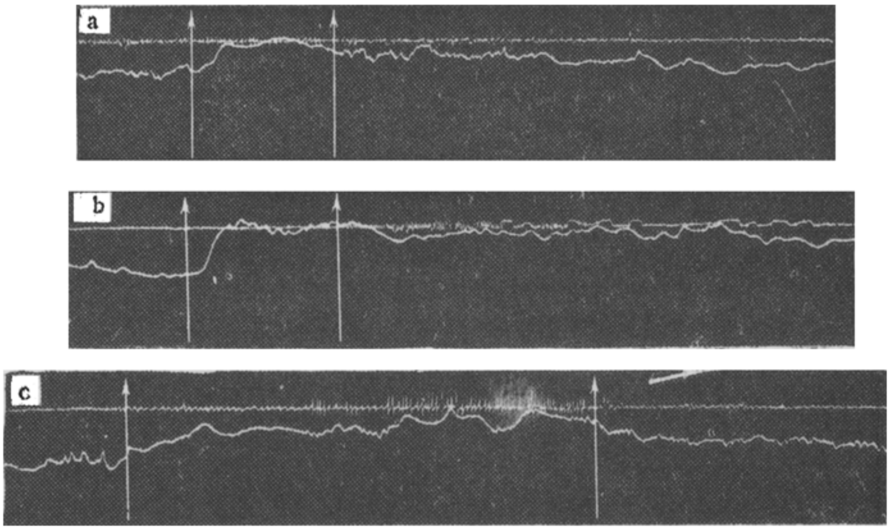

Fig. 1. Changes in the rate of flow in coronary arteries of dogs.
a) Feeding: b) distention of the rectum; c) display of a cat. Explanation of curves (from above down): respiration, rate of flow of blood. The arrows indicate commencement and termination of stimulus.

The effects of painful electrical stimulation of a hind leg on the rate of flow in a coronary artery are shown in Figure 2.

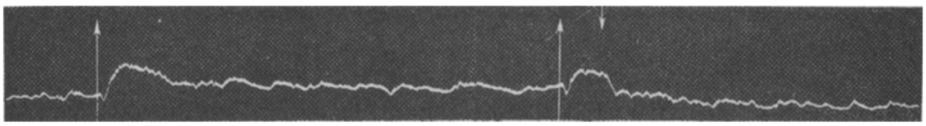

Fig. 2. Effect on coronary blood flow of electrical stimulation of a leg.
Explanation of curves as for Figure 1. The arrows↑↑ indicate duration of painful stimulation, and the arrow↓ indicates the moment of fall of the instrument, which frightened the dog.

A transient fall in flow-rate, followed immediately by a rise, was observed at the beginning of the period of painful stimulation. This initial fall in flow-rate was a regular feature of these experiments. It is highly characteristic of the effect of painful stimulation that whereas the effect of the stimuli described above was undirectional, leading to rise in flow-rate only, the rate of supply of blood to the heart diminished only at the moment of application of painful stimuli. This phenomenon was observed whenever the experiment was repeated, whether on the same day or on different days.

The diminution in the supply of blood to the heart at the moment of initiation of painful stimulation is evidently due to its powerful, violent, and abrupt action on the nervous system. This view is supported by the following observations. During one of the experiments on painful stimulation a dog standing on the bench began to struggle after a fairly strong current had been switched on, and knocked over one of the instruments, which fell to the floor with a loud clatter. This intensified the emotional state of the dog. In this, as in all other experiments of this type, a brief fall in flow-rate was observed immediately after initiation of the painful stimulus, followed by a rise, but it is noteworthy that after the fall of the instrument the rate of flow fell rapidly to below the initial level, as is shown in Figure 2. During another experimenton the effect of static loading the harness carrying the load accidentally slipped forward and downward, leading to an unexpected compression of the chest, which frightened the dog, causing it to struggle. Here,too, we observed a marked fall in the rate of flow of blood.

The effects on the rate of flow in the coronary artery of painful stimuli and of feeding remained the same over the whole period of observation following the operation.

One dog with an indwelling thermoelectrode died on the 42nd day after operation. Up to the day of its death the dog showed no external symptoms or signs of ill-health. Marked changes in the electrocardiogram were, however, seen two days before it died.

The above data illustrate the importance of the study of the physiology and pathology of the coronary circulation in unanesthetized animals. Under such conditions it is possible to follow changes in the blood supply of the heart due to various environmental factors, such as feeding, muscular exertion, etc.; such observations would not be possible under the conditions of a short experiment. Moreover, the experiments on painful stimuli gave clear evidence of the effect of the functional state of the central nervous system on the reaction of the coronary arteries during the experiment.

LITERATURE CITED

[1] M. E. Marshak and M. M Voll, Arkh. Biol. Nauk SSSR, 63, No. 3, 40-48 (1941).

[2] H. E. Essex, J. F. Herrick, E. J. Baldes and F. C. Mann, Am. J. Physiol., 1936, Vol. 117, No. 2, pp. 271-279.

[3] A. K. Noyons, M. von Westenrijk and J. Jongbloed, Arch. neerl. de physiol., 1936, Vol. 21, pp. 377-432.

REFLEX EFFECTS ON VASCULAR TONUS FROM CARDIAC MECHANORECEPTORS

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One of the first indications of the existence of receptor functions of the myocardium and endocardium emerged from the so-called Bezold-Jarisch effect.

Bezold and Hirt [4] found in 1867 that injections of veratrine slowed the action of the heart. They interpreted this effect as being a cardiocardiac reflex. Similar effects were described by Jarisch and Henze [6] and by Richter and Schrockschnadel [9]. According to Jarisch, this reaction is effected through cardiac mechanoreceptors, the sensitivity of which is raised by veratrine; the effect involves stimulation of the vagus, with inhibition of sympathetic nerves.

Schaeffer [10] and others showed later that volleys of impulses from cardiac branches of the vagus are as a rule synchronous with contraction of the heart, but under the influence of veratrine the impulses become contínous (Jarisch and Zotterman [7]). The action of veratrine is exerted on receptors situated in the left ventricle (Schaeffer [10]).

A considerable number of papers have been published over the last few years, dealing with the study of the mechanisms of the nervous pathways of the Bezold-Jarisch reflex (see the detailed review by Dawes and Comroe [5]).