THE INOTROPIC AND CHRONOTROPIC COMPONENTS OF THE CARDIAC ACTIVITY OF DOGS AT REST

L. N. Deryabin

From the I. M. Sechenov Institute of Evolutionary Physiology (Director — Academician L. A. Orbeli) of the Acad. Med. Sci. USSR

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Clinically there are distinguished [2] a "basal" or "residual" intra-arterial pressure, which is the lowest level obtained in repeated measurements in the absence of digestion and physical effort, and an "active", "chance" or "ordinary" pressure, obtained by the first measurement during a period of activity by the subject examined. Under these circumstances the transition from the "ordinary" to the "basal" pressure lasts 5-10 minutes.

In research carried out on dogs [6] it was shown that the values of the intra-arterial pressure fall if taken every day, reaching their lowest level in the course of a week. In some analogous investigations [11, 12] it was found that the process of this fall in pressure may last for several months. These authors, who experimented on dogs, were not concerned with determining the course of the changes in these values in the course of an isolated experiment. Nevertheless this is important in order to find out the mechanism of nervous influence on the heart when the animal is recovering in a state of rest.

Our aim was to discover the quantitative and qualitative features of the changes in the inotropic and chronotropic components of the cardiac activity of dogs during the period of transition from ordinary activity to the resting state, when kept in the laboratory for the course of the experiment. In carrying out this task it was necessary to determine the strength of the cardiac contractions by a method of bloodless examination. Among the various parameters of the variations in the intra-arterial pressure, the one that most often satisfies the requirements of such an investigation is the magnitude of the final maximum pressure (FMP). The basis of this choice is the idea [9] that the FMP reflects the whole potential and kinetic energy of the blood moving along the vessel at the point of measurement. In view of the fact that in the higher vertebrates the main source of energy of movement of the arterial blood is the heart, the FMP may act as an index of the energy developed by the heart muscle in the process of contraction. This is in accordance with clinical observations [1, 5, 7 and others], showing that the FMP reflects the work of the heart and the strength of its contractions.

EXPERIMENTAL METHOD

The experiments were performed on dogs in an ordinary experimental chamber, not screened from extraneous sounds. During the experiment the animal lay on the floor or in a cradle in a convenient position. The FMP was determined in the "intermammillary" vessels or in the central caudal artery every 1-2 minutes throughout the experiment, by means of a mechanocardio-oscillograph [4]. In each experiment from 15 to 50 measurements were made. At the same time continuous sphygmography was carried out, the results of which were used to ascertain the average frequency of cardiac contractions (FCC) and as an indicator of the degree of compression of the vessel during the determination of the FMP. The experiments were discontinued if the animal passed into a state of prolonged excitation. The FMP was estimated in mm of mercury.

EXPERIMENTAL RESULTS

Altogether we carried out 122 experiments on 4 dogs. It was found that in the conditions described above, the value of the FMP and FCC in these dogs gradually fell. This can be seen from the example of the experiment (with the dog Naida) of which the results are shown in Fig. 1: in the course of 25 minutes the value of the FMP fell by 35 mm and that of the FCC by 27 per minute. We then deduced the mean values each minute of the chronotropic and inotropic indices for all the experiments carried out with each dog. The mean values obtained were treated graphically in two ways. In the first variant values were not excluded which coincided with the action of extraneous sound stimuli; in the second variant the calculation of the mean values was preceded by exclusion of those results which coincided with these stimuli, until the values had returned to their initial level. In Fig. 2 are shown the results of 22 experiments carried out on the dog Trezor. It can be seen from this figure that the combined results for all the experiments also reflected the fall in the values of the FMP and FCC. We performed analogous experiments on 3 more dogs with the same results. In one of these dogs – Laski – a few years before the experiments the spinal cord had been divided in the lower thoracic region, and the abdominal sympathetic chains had been removed. We give a table which summarizes the results of the experiments on all the dogs which were studied.

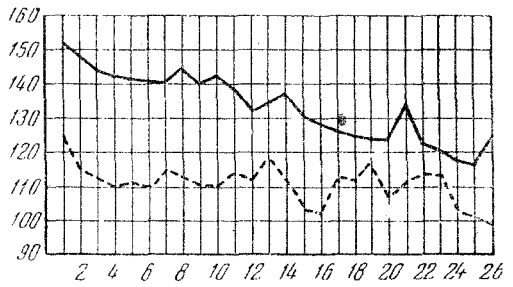

Fig. 1 Changes in the value of the final maximum pressure (FMP) and the frequency of cardiac contraction (FCC) in the dog Naida at rest.
Legend: along the ordinate axis – values of the FMP (in mm of mercury) and the FCC (per minute); along the abscissa – duration of the experiment (in minutes): ——— FMP, – – – – FCC.

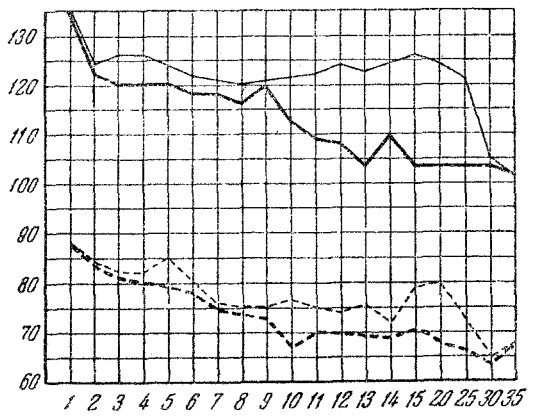

Fig. 2. The FMP and FCC of the dog Trezor at rest.
Legend: thin lines – first variant, thick lines – second variant (for explanation see text); remaining legend as in Fig. 1.

The experimental results showed that when the dog lay at rest there was a fall in the value of the FMP, as is also observed in human subjects on repeated examination in a state of rest. The duration of this process in animals reached 45 minutes in individual cases, compared with 5-10 minutes in man. On the average for all the experiments, in 35 minutes the FMP fell by 27.5 mm and the FCC by 26.5 per minute (second variant). There were two possible explanations of this phenomenon. The first was derived from the standpoint of the general functions of the circulation of the blood as an apparatus responsible for the adaptability of the body toward changed conditions of existence and maintaining the constancy of the internal environment of the body at the most favorable level for its vital activity [8]. According to this view, the fall which we observed in the inotropic and chronotropic indices could be regarded as the manifestation of a lowering of the general physiological activity of the dogs in the process of rest. The second was based on the hypothesis that when the animal was at rest the vascular tone was diminished, which was also the cause of the fall in the values of the FMP. Edens [3], who observed a fall in the blood pressure during repeated measurements in the course of 4-5 minutes, provisionally explained this as due to a fall in the resistance of the vessel wall under the action of compression in the process of measurement. This explanation, so simple and logical at first sight, conflicts with certain experimental findings.

Artificial increase of the tone of the vessel wall due to the action of adrenaline leads to a fall, but a decrease of the tone (by cocaine) leads to a rise in the external pressure required for compressing the vessel [10]. These experiments were in agreement with the clinical findings (angiospastic states) which suggested that an increase in vascular tone may cause intravascular occlusion of varying degree without the addition of an external compressing agent. This seemed to indicate that the direction of the

force during artificial or natural increase in the tone of the vessel wall coincides with the direction of the compressing agent during the determination of the FMP.

Changes in the Inotropic and Chronotropic Indices of Cardiac Activity of an Animal in a State of Rest (the dog in recumbency)

Name of dog	Number of experiments	Vessels used in the experiments	At the beginning of the experiments		At the end of the experiments		Fall in the values in the course of the experiments		Duration of the experiments, in minutes
			FMP	FCC	FMP	FCC	FMP	FCC	
Rozka	15	Intermammillary	116	126	106	95	10	31	30
Laska	20	The same	121	98	85	76	36	22	30
Trezor	22	Caudal artery	134	88	103	64	31	24	35
Naida	55	The same	139	102	106	73	33	29	45
Average	112	—	127,5	103,5	100	77	27,5	26,5	35

In connection with the above it became evident that the reduction in the tone of the vessels could not be the cause of the fall in the FMP if we were limited to a consideration of the factor described above. Experiments carried out on the dog Laska, in which the FMP was measured in vessels deprived of central nervous tonic influences from the brain, showed that a fall took place in the FMP as it did in the intact animals. If the cause of the fall in the FMP which we observed was a corresponding fall in tonic influences, then in the conditions of the experiments on this dog, the FMP would not have fallen when the dog was at rest. The fall in the above-mentioned values in this animal could be attributed to humoral factors, but then it would have to be accepted that these factors acted in isolation from the nervous influences, which is incorrect. It follows from the foregoing that the fall in the FMP and FCC which we observed in dogs in the resting state was a manifestation of changes in the adaptational-trophic influences acting on the heart.

The experimental findings which we obtained justify the conclusion that a state of rest (recumbency) in dogs in an ordinary experimental chamber is accompanied by intensification of negative inotropic and chronotropic influences on the activity of the heart. These changes, observed in experiments lasting up to 45 minutes, were present in both intact dogs and an animal in which the vessels at the point of measurement were deprived of tonic nerve influences from the brain.

SUMMARY

The values of the final maximal intra-arterial blood pressure and the average frequency of cardiac contractions were studied in 4 dogs which lay at rest. In experiments of up to 50 minutes there occurred a gradual reduction of these values depending on the duration of the rest period. This regularity was observed both in dogs intact and in animals whose vessels were not subject to the cerebral neural tonic effect at the site of examination.

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