ELASTIC PROPERTIES OF THE ATRIUM AND CHARACTERISTICS OF THE ATRIAL MECHANORECEPTORS

E. P. Anyukhovskii and G. G. Beloshapko

UDC 611.125:611.8

Combined activity of the mechanoreceptors of the right atrium, the pressure inside the atrium, and stretching of its wall were recorded in acute experiments on cats. The elasticity of the atrium falls sharply under a pressure of more than 4-5 mm Hg. Under a high pressure, on the other hand, the sensitivity of the mechanoreceptors to stretching of the atrium increases sharply. Consequently, a linear relationship between intra-atrial pressure and mechanoreceptor activity still holds good, so that these receptors can provide information to the CNS on the intra-atrial pressure as it changes over a wide range of values.

KEY WORDS: atrial mechanoreceptors; intra-atrial pressure.

Characteristics of the atrial mechanoreceptors have hitherto been studied by recording the electroneurograms of single receptors (fragments of the teased vagus nerve) [1, 4]. These investigations showed that with an increase in stretching of the atrium the number and frequency of impulses in volleys from the mechanoreceptors rise. In these experiments the atria were stretched by intravenous injection of dextran, by stenosis of the pulmonary artery, or by means of a special expander introduced into the atrium through the auricle [2, 6]. However, these methods are unsuitable for quantitative determination of the degree of stretching of the atria.

The object of this investigation was to determine quantitative relations between activity of the atrial mechanoreceptors, the pressure inside the atrium, and the stretching of its wall.

EXPERIMENTAL METHOD

Cats were anesthetized with chloralose and urethane for the experiments. Combined activity was recorded from a branch of the right inferior cardiac nerve running close to the azygos vein, so that the activity of many receptors in the zone of the right atrium could be analyzed. Since most activity of the atrial mechanoreceptors takes place during diastole, the integral of this activity, determined over a certain constant period during diastole, was taken as the quantitative characteristic of receptor activity. For this purpose the electroneurogram was led by means of an AKS-1 cardiosynchronizer and relay to the input of an IÉ-I integrator during the 0.2-0.3 sec (depending on the initial heart rate) after the R wave of the ECG.

To measure the diameter of the atria, a special circular pick-up was made on the basis of a design suggested by Mallos [3]. The sensitive element of this pick-up consisted of two strain gauges glued to a thin brass bridge placed between the legs of dividers. At the ends of the dividers there were holes for suturing to the walls of the atrium. One leg of the dividers was stitched to the base of the inferior cava, the other to a point diametrically opposite, at the base of the auricle of the right atrium. Because of the thinness of the brass bridge, only a very slight force was required to move the legs of the dividers, and virtually no obstacle was created to deformation of the atrium. The increase in pressure in the right atrium, measured by means of an electromanometer, was produced by stenosis of the pulmonary artery. All parameters were recorded on the Mingograph-1600 apparatus.

Laboratory of Physiology and Pathophysiology of the Circulation, A. L. Myasnikov Institute of Cardiology, Academy of Medical Sciences of the USSR, Moscow. (Presented by Academician V. N. Chernigovskii).
Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 81, No. 2, pp. 140-141, February, 1976. Original article submitted January 5, 1975.

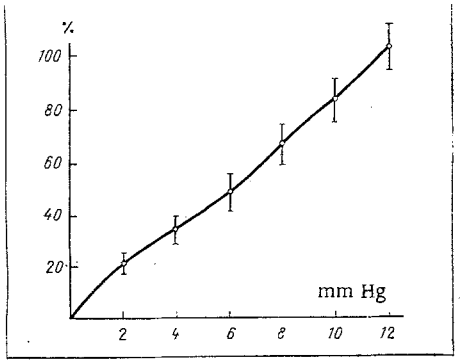

Fig. 1

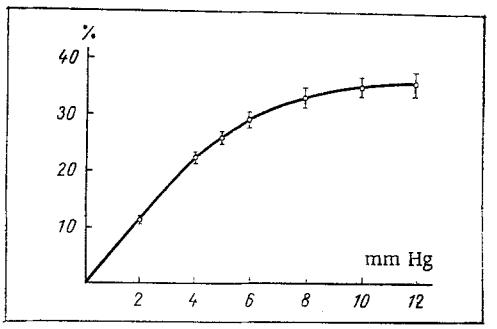

Fig. 2

Fig. 1. Dependence of activity of atrial mechanoreceptors on intra-atrial pressure. Here and in Figs. 2 and 3 values of $M \pm \sigma$ are given. Abscissa, mean intra-atrial pressure (in mm Hg); ordinate, increase in mechanoreceptor activity (in % of its activity at with zero intra-atrial pressure).

Fig. 2. Dependence of stretching of atrium on intra-atrial pressure. Abscissa, mean intra-atrial pressure (in mm Hg); ordinate, increase in diameter of atrium (in % of its diameter at zero pressure).

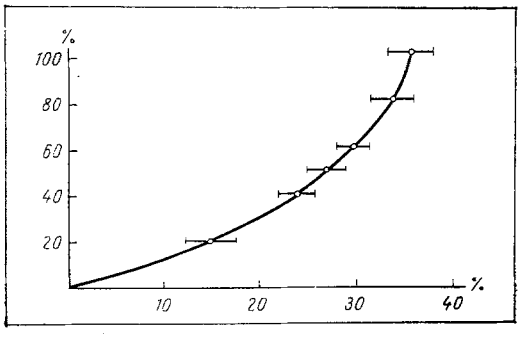

Fig. 3. Dependence of activity of atrial mechanoreceptors on stretching of atrium. Abscissa, increase in mean diameter of atrium (in % of its diameter at zero pressure); ordinate, increase in mechanoreceptor activity (in % of activity at zero intra-atrial pressure).

EXPERIMENTAL RESULTS

Data obtained in experiments on nine animals were analyzed. Activity of the atrial mechanoreceptors as a function of intra-atrial pressure is shown in Fig. 1. Up to 12 mm Hg receptor activity was proportional to pressure (if the intra-atrial pressure exceeded 12 mm Hg severe bradycardia usually developed and the pressure fell). On the other hand, stretching of the atrium was a nonlinear function of intra-atrial pressure (Fig. 2). Starting from 4-5 mm Hg, the rate of increase in the atrial diameter fell sharply as the pressure increased. Similar results were obtained by Payne and co-workers [5], who studied the elasticity of the atria in dogs.

Activity of the atrial mechanoreceptors is shown in Fig. 3 as a function of stretching of the atrium. Clearly up to 20-25% stretching of the atrium (incidentally, with this level of deformation of the atrium its elasticity falls sharply – see Fig. 2), activity in the nerve was proportional to stretching of the atrium. With higher degrees of stretching of the atrium, the rate of increase of activity in the nerve increased sharply. This increase in the rate of rise of activity in the nerve could be due either to the nonlinear relationship between the firing rate of individual mechanoreceptors and the degree of their deformation or to the activation of mechanoreceptors with high excitation thresholds in response to stronger stretching of the atrium.

What is the informative value of impulses from the atrial mechanoreceptors? Do they provide information about the intra-atrial pressure or about the degree of stretching of the atrial wall? The fact that combined activity of the atrial mechanoreceptors is proportional to the intra-atrial pressure suggests that the function of the atrial mechanoreceptors is to send information to the CNS about the level of the intra-atrial pressure. If the pressure in the atrium is low, the elasticity of its wall is high (Fig. 2). Naturally, at higher levels of intra-atrial pressure, elasticity of the atrium must decrease, for otherwise the dimensions of the atrium under high pressures would be very great. However, the characteristics of the atrial mechanoreceptors are such that the rate of growth of their combined activity rises during high degrees of

stretching of the atrium. This compensates for the decrease in elasticity of the atrium under high intra-atrial pressure. A linear relationship thus continues to hold good between the intra-atrial pressure and activity of the atrial mechanoreceptors; consequently, these receptors can send information to the CNS on the intra-atrial pressure.

LITERATURE CITED

1. F. P. Yasinovskaya, Dokl. Akad. Nauk SSSR, 173, 937 (1967).
2. F. P. Yasinovskaya and G. G. Beloshapko, Kardiologiya, No. 5, 104 (1973).
3. A. J. Mallos, J. Appl. Physiol., 17, 131 (1962).
4. A. S. Paintal, Physiol. Rev., 53, 159 (1973).
5. R. M. Payne, H. L. Stone, and E. Engelken, Fed. Proc., 28, 517 (1969).
6. K. Sassa and H. Miyazaki, J. Physiol. (London), 54, 203 (1920).