CONNECTION BETWEEN THE STRUCTURAL ORGANIZATION OF THE AORTIC BARORECEPTOR ZONE AND CHARACTERISTICS OF THE BARORECEPTORS

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In experiments on a preparation of the aortic arch of cats and rabbits the overall electrical activity of the left aortic nerve was recorded in response to different pressures in the aorta, With a decrease in pressure, activity in the nerve was reduced, but at very low pressures (40 mm) some increase in activity was observed, more so as the pressure fell further. At the moment of onset of these "negative" discharges no sign of collapse of the vessel walls occurred. It is suggested that the appearance of the "negative" discharges and the variation of the threshold pressures of the baroreceptors can be explained by the structural organization of the baroreceptor zone.

Characteristics of the baroreceptors of the aortic arch and carotid sinus have been studied in experiments on several species of animals. In every case the overall electrical activity of the aortic or sinus nerve when plotted against pressure follows an S-shaped curve: with an increase in pressure in the aorta or carotid sinus activity in the nerve rises once a certain threshold is attained and reaches a maximum at a certain pressure [1, 4, 15]. In experiments on single fibers of the aortic and sinus nerves a similar relationship was found between impulse frequency and pressure [5, 6, 8]. Considerable variation in the thresholds of the baroreceptors is found (from 30 to 90 mm Hg). Some workers have observed atypical, "paradoxical" discharges from certain baroreceptors, appearing at low pressures and increasing as the pressure falls further in the aorta or carotid sinus. Such discharges, described as "negative" discharges of the baroreceptors, have been found in experiments both on single fibers [9] and on the whole nerve [16]. Workers who have recorded these "negative" discharges consider that they are caused by deformation of the baroreceptor zone as a result of collapse of the vessel walls when the intravascular pressure is low.

The object of this investigation was to determine more accurately the pressures in the aorta and its deformations which lead to the appearance of negative discharges. An explanation of this phenomenon and of the variation in theshold pressures for single receptors is suggested on the basis of the structural organization of the aortic baroreceptor zone.

EXPERIMENTAL METHOD

Experiments were carried out on a preparation of the aortic arch of rabbits and cats. The aortic arch was isolated by applying a ligature to the innominate and left subclavian arteries and to the descending part of the aorta. A copper cannula connected to a coil made of a thin glass tube was introduced through the left ventricle into the aortic orifice. The coil was filled with the animal's heparinized blood and connected by a flexible tube to a reservoir filled with mercury. The pressure in the preparation was varied by moving the reservoir containing mercury in a vertical direction, and the degree of stretching of the aorta was estimated from the displacement of the blood–mercury boundary (at a pressure below 200 mm

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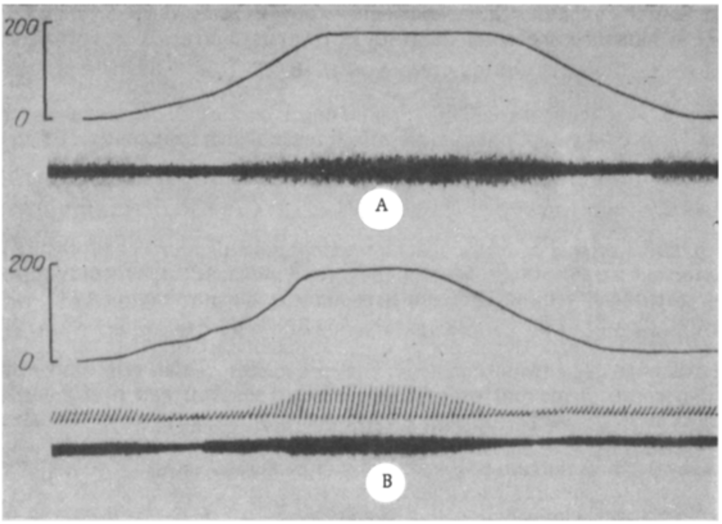

Fig. 1

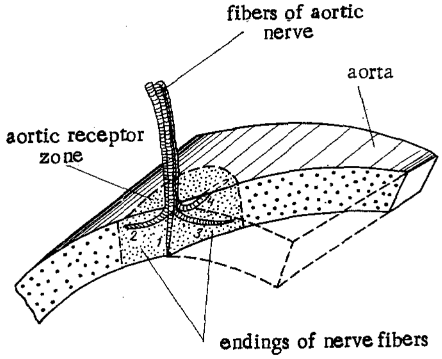

Fig. 2

Fig. 1. Electroneurogram (ENG) of left aortic nerve of a cat (A) and rabbit (B). A: top curve – pressure in aorta (in mm), bottom curve – ENG; B: top curve – pressure in aorta (in mm), middle curve – integration of nerve activity (period of integration 0.5 sec), bottom curve – ENG.

Fig. 2. Diagram of branching of nerve endings in aortic baroreceptor zone (explanation in text).

Hg the length of the segment of aorta remains practically constant [13, 14]). The overall electrical activity of the left aortic nerve was recorded and integrated.

By performing experiments on such a preparation, it is possible to investigate receptor activity at very low pressures (down to zero), and possible nervous and humoral influences on the baroreceptor zone are eliminated.

EXPERIMENTAL RESULTS

Activity of the left aortic nerve of the cat and rabbit, respectively, at different levels of pressure in the aorta is illustrated in Fig. 1A and B. It will be seen that impulses were recorded in the nerve when the pressure was zero. In response to a gradual increase in pressure the activity first decreased to reach a minimum at 30-40 mm Hg, after which it increased. As the pressure in the aorta fell, a similar change in baroreceptor activity was observed. Quantitative analysis of the overall activity showed that the power of the negative discharges did not exceed 10% of the maximal activity in the nerve.

Do the negative discharges appear because of deformation of the receptor zone caused by collapse of the aortic walls? When the pressure reached 30-40 mm Hg (i.e., at the moment of appearance of the negative discharges on a decrease in pressure in the preparation) the aorta was cylindrical in shape and, as calculations of the stretching of the aorta showed, its radius at this pressure was 20-30% greater than the radius at zero intravascular pressure. At the moment of appearance of the negative discharges no collapse of the aortic walls has thus taken place.

In that case, what can cause the appearance of discharges from the baroreceptors at low intravascular pressures? Morphological investigations have shown that baroreceptor nerve endings form extensively branching structures [2, 3, 12]. Some of them run from the surface of the vessel to its longitudinal axis, i.e., along the radius of the vessel (receptor 1 in Fig. 2). Deformation of this type of receptor is produced by a change in the thickness of the vessel wall. During deformation of the aorta the volume of substance of the vessel wall is known to remain unchanged [11]. In other words,

$$R_0 \cdot \delta_0 = R \cdot \delta,$$

where R_0 and δ_0 represent the radius and thickness of the aortic wall at zero pressure within the vessel; R and δ represent the same parameters at a given pressure. In that case

$$\delta = \frac{R_0 \cdot \delta_0}{R},$$

i.e., the thickness of the vessel wall is inversely proportional to its radius. Since with a decrease in pressure in the aorta its radius is reduced, the thickness of the wall increases correspondingly. At a certain pressure, deformation of ending 1 (Fig. 2) exceeds the threshold, causing the appearance of discharges whose frequency increases with a further decrease in the pressure.

Branching of the receptor endings also explains the variation in threshold pressures of the individual receptors. Since with an increase in pressure in the aorta its radius increases while its length remains practically unchanged [13, 14], deformation of endings arranged tangentially, i.e., in the direction of the tangent to the surface of the vessel (ending 2 in Fig. 2), occurs primarily, and it is only at very high pressures that the endings arranged along the axis of the vessel (ending 4 in Fig. 2) undergo deformation. Receptor 2 must therefore have the lowest threshold and receptor 4 the highest threshold. The thresholds of all other endings are distributed within this range depending on their direction. The absence of activity in the aortic nerve at a pressure of 30-40 mm Hg (Fig. 1) can be explained in this case by the fact that at this pressure the radius of the aorta is too small for the deformation of the receptors arranged tangentially to exceed the threshold, and too small to cause excitation of the nerve endings running radially.

The function of the "negative" discharges is not yet clear. With a considerable drop of pressure (below 50 mm Hg) cessation of impulses from the baroreceptors is insufficient itself to produce mobilization of all the mechanisms maintaining the circulation and an additional stimulus is required, such as the negative discharges. On the other hand, it has been shown [7] that a very low pressure in the isolated carotid sinus (below 40 mm Hg) produces some decrease in the arterial pressure. Landgrehr [10] considers that these receptors cannot play an essential role in the development of hypotension because of their small numbers. However, the few investigations so far undertaken do not allow final conclusions to be drawn regarding the role of the baroreceptors working at low pressures.

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