PHYSIOLOGICAL CHARACTERISTICS OF THE CARDIAC BRANCHES OF THE RECURRENT NERVES

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Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 54, No. 9,
pp. 14-18, September, 1962
Original article submitted November 16, 1960

The authors of several anatomical papers [1, 3, 6, 12, 13 and others] have cited facts indicating that the recurrent nerves are concerned in the innervation of the heart. At the same time there are fragmentary details in the literature concerning the physiological characteristics of the branches of these nerves.

The recurrent nerve is, of course, a component of the vagus. The recurrent nerves differ from the superior laryngeal nerves by the complexity of the structure of their bundles, and they may be regarded as nerves forming plexuses within their own trunks [9]. According to the anatomical data, the recurrent nerves anastomose with the middle cervical ganglion [3, 6], the stellate ganglion [11], the depressor nerve [1], Pavlov's intensifying nerve, and the cardiac branches of the vagus nerve [13]. The communication between the recurrent nerves and the parasympathetic and sympathetic systems, and also the presence of plexuses within the nerve trunks themselves, indicate that the recurrent nerves are mixed nerves.

V. T. Serebrov [8] considers on the basis of numerous investigations that the division of the autonomic nervous system by morphological analysis into sympathetic and parasympathetic is not fully justifiable anatomically, for anastomoses between these systems are found if the principal trunks are traced from the center to the periphery. The cardiac branches of the recurrent nerves take part in the formation of the aortic plexus [6, 11], the anterior atrial plexus, and the plexus at the mouth of the anterior vena cava [4], and they innervate the ductus arteriosus [7]. The cardiac branches of the left recurrent nerve innervate not only the left, but also the right atrium, the right and left auricle, and the right ventricle of the heart [5].

V. N. Velikii and I. P. Pavlov [2] deduced conclusions opposite to those of Schiff. They considered that the fibers of the accessory nerve of Willis, accelerating the heart beat, could not pass in the laryngeal nerves. Their experiments confirmed that these fibers pass from the spinal cord through the stellate ganglion.

In our investigation we attempted to describe the physiological characteristics of the cardiac branches of the recurrent nerves, and at the same time to verify these characteristics anatomically.

EXPERIMENTAL METHOD

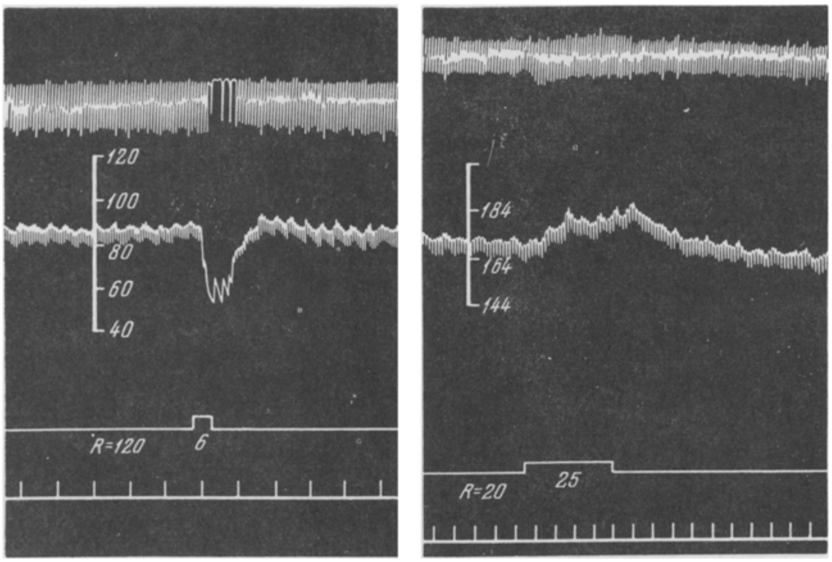
Acute experiments were carried out on animals (34 cats and 5 dogs). The animals were anesthetized by the intraperitoneal injection of 20% urethane solution in a dose of 1 g/kg body weight for cats and 1.5-2.0 g/kg body weight for dogs. Before opening the chest, to prevent bleeding from the intercostal vessels, the ribs from 1 to 8 were included in interrupted sutures on both sides of the line of the incision. Artificial respiration was then applied to the animals.

The recurrent and vagus nerves were dissected out and taken up in ligatures; they were then stimulated with an induction current in different anatomical areas before and after division at different levels depending on the purpose in mind. The strength of stimulation was determined by the distance between the induction coils.

In the course of the experiments the arterial pressure was recorded by means of a mercury manometer connected to a cannula inserted into the carotid artery, and the changes in the volume of the heart were recorded by means of a pericardial cannula connected to a highly sensitive capsule.

EXPERIMENTAL RESULTS

In 16 of the 20 cats stimulation of the right and left recurrent nerves in the thorax, at the point where they gave off their cardiac branches, caused slowing of the heart beat and a fall in arterial pressure (Fig. 1, A), while in four cats the arterial pressure was seen to rise and then fall, the heart rate slowed, and the amplitude of the cardiac contractions increased.



A B

Fig. 1. Effect of stimulation of the right recurrent nerve of a cat in the thorax, at the point at which it gives off its cardiac branches (A), and of the peripheral end of the left recurrent nerve of a cat after division of the nerve in the thorax at the point at which it arises from the vagus nerve (B).

Stimulation of the peripheral ends of the recurrent nerves after their division in the thorax, at the point at which they arise from the vagus nerves, was carried out in six cats on the left side and in eight on the right. In 11 cases a rise of arterial pressure was observed (Fig. 1, B), and in four the cardiac activity was modified. In three animals an increase in the stroke volume of the heart was observed during stimulation of the peripheral end of the left inferior laryngeal nerve, while in one cat weak stimulation of the right recurrent nerve caused a decrease in the stroke volume of the heart, while stronger stimulation caused an increase.

Stimulation of the cardiac branches directly, without preliminary separation of the branches from the recurrent nerves, was carried out in four cases and led to a fall in the arterial pressure and a slowing of the heart beat.

In all five dogs, stimulation of the uninjured right recurrent nerve in the thorax, at the point where it gives off its cardiac branches, caused a slowing of the heart beat and the appearance of a vagus pulse.

After division of the right recurrent nerve in the thorax, at the point of its origin from the vagus nerve, its peripheral end was stimulated in the dogs. Stimulation of the peripheral end led in all cases to a slowing of the heart beat and to the appearance of a vagus pulse.

In the experiments on dogs we were able to make a more detailed dissection of the cardiac branches of the recurrent nerves and to stimulate each branch individually. We have pointed out above that the initial, convex portion of the recurrent nerve gives origin to two or three branches to the heart, and communicating branches to the vagus nerve and to the middle cervical ganglion. The anatomical picture of the ramification of the cardiac branches of the recurrent nerves differed in the experiments on the dogs, so that it will be expedient to describe three cases.

In one experiment (Fig. 2, A) three branches arose from the ventrocaudal region of the convexity of the recurrent nerve. The first (1) and third (3) branches united to form a single branch on their way to the heart. The second branch (2) joined an anastomotic branch from the first branch to the cardiac branch of the vagus nerve. In this experiment the first branch (1) was stimulated at a distance of 2 mm from its origin from the convexity of the recurrent nerve. Depending on the strength of stimulation, certain differences in its effects were observed: if the induction coils were 170 mm apart the arterial pressure fell, a vagus pulse appeared, and the heart beat was slowed; if the coils were 190 and 200 mm apart, the arterial pressure fell and a vagus pulse appeared at the time of stimulation, while the arterial pressure rose again at the end of stimulation.

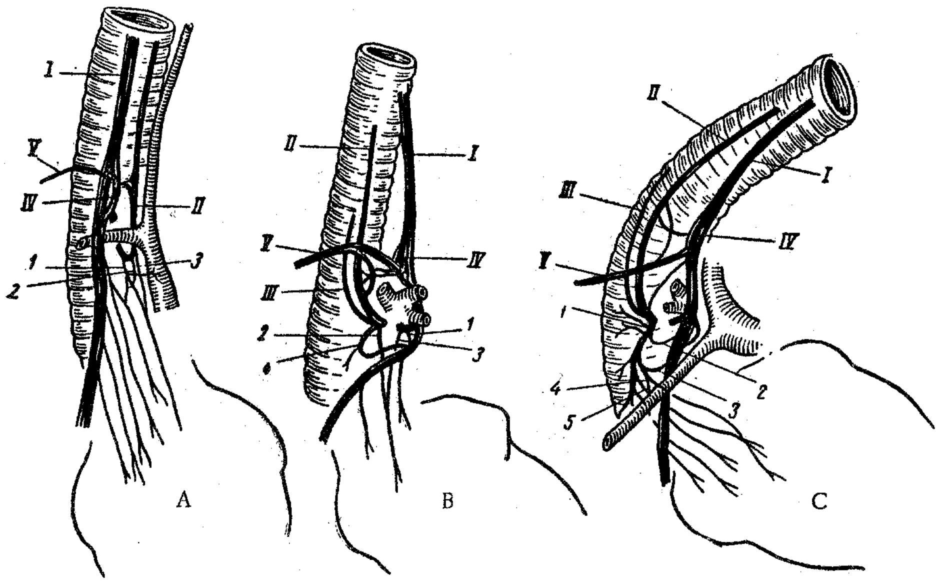


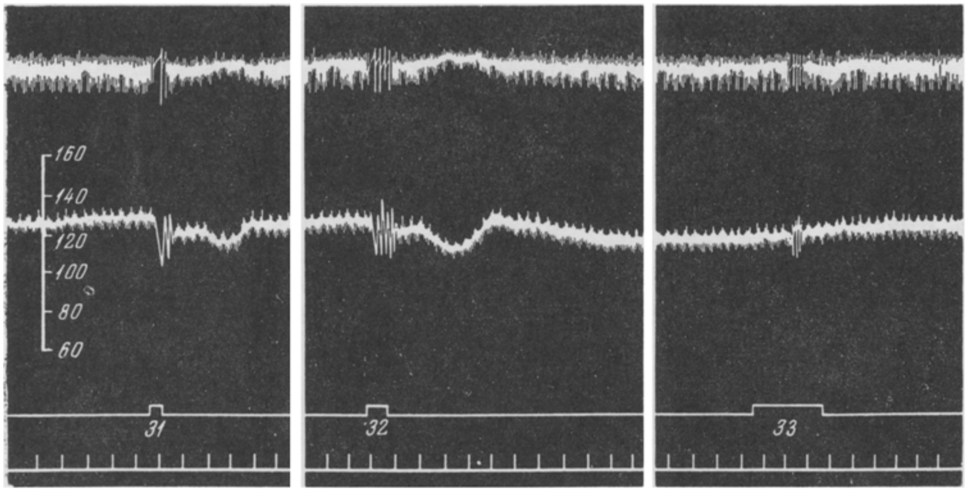
Fig. 2. Scheme of ramification of the cardiac branches of the right recurrent nerve of the dog. I–vagus nerve; II–recurrent nerve; III–accessory recurrent nerve; IV–middle cervical ganglion; V–sympathetic nerve. A, B, C–different patterns of ramification of the cardiac branches of the recurrent nerve.

In another experiment (Fig. 2, B and Fig. 3), four branches arose from the initial and convex portions of the recurrent nerve. Two of these (see Fig. 2, B) united after a course of 20 mm, and turned towards the base of the heart. The other two (1, 4) branches connected the recurrent nerve with the trunk of the vagus nerve. The direction of these branches differed. One branch (3) approached the vagus nerve trunk dorsocaudally, the other (4) ventrocaudally. Simultaneous stimulation of the second and fourth branches led to a lowering of the arterial pressure, and to the appearance of a vagus pulse. At the end of stimulation a lowering of the arterial pressure was observed, with dilatation of the heart chambers, a decrease of the stroke volume of the heart, and incomplete expulsion of blood from the heart chambers (see Fig. 3, A). A similar effect was observed during stimulation of the fourth branch, connecting the recurrent nerve with the vagus (see Fig. 2, B, 4 and Fig. 3, B). Stimulation of the second branch alone led to the appearance of a vagus pulse (see Fig. 2, B, 2 and Fig. 3, B).

The first and third branches (see Fig. 2, B, 1, 3) were not stimulated by the induction current, for a detailed dissection of these branches was impossible in the acute experiment because of their intimate connection with the vagus nerve trunk.

In the third experiment (see Fig. 2, C) a fairly thick trunk (1) branched from the recurrent nerve in its initial portion, which descended towards the heart and divided into numerous branches. Two branches (2, 3) immediately joined the vagus nerve trunk. Two others (4, 5) ran towards the heart and anastomosed with the cardiac branches of the vagus. In addition, a few branches (6) approached the trachea. Stimulation of the nerve trunk itself at its origin from the recurrent nerve caused an increase of arterial pressure. During stimulation of this trunk immediately after the departure of the branches to the trachea and of one branch to the vagus nerve, we observed, as in the first case, an increase in arterial pressure. Stimulation of the third branch (3), communicating with the vagus nerve trunk, led to the appearance of a vagus pulse and to slowing of the heart rate. An elevation of the arterial pressure was observed during stimulation of the fourth branch (4), directed towards the heart.

The anatomical findings and the experimental results described above indicate that the recurrent nerves play a part in the regulation of the arterial pressure and of the activity of the heart. The fact that stimulation of the peripheral end of the recurrent nerve and its cardiac branches (after preliminary division of the recurrent nerve in



A B C

Fig. 3. Effect of stimulation of the cardiac branches of the right recurrent nerve of a dog in the thorax.

the thorax, at its point of origin from the vagus nerve) leads to a change in the level of the arterial pressure and to slowing of the heart rate demonstrates that the recurrent nerves contain efferent fibers taking part in the innervation of the heart. The pressor and depressor effects during stimulation of the recurrent nerves and of their cardiac branches confirm the opinion held by anatomists that the recurrent nerves are mixed in nature.

SUMMARY

The cardiac branches of recurrent nerves in 34 cats and 5 dogs were studied in acute experiments. The data obtained testify to the presence in recurrent nerves of afferent and efferent nerve fibers involved in the regulation of the arterial pressure and cardiac activity. Upon stimulation of recurrent nerves as well as their cardiac branches depressor and pressor effects were observed, this giving grounds to consider recurrent nerves as an intermediate type. This is confirmed by a number of anatomic studies of different authors.

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