ORIGIN OF THE "SPONTANEOUS" VOLLEYS OF IMPULSES IN THE CARDIAC BRANCHES OF THE VAGO-SYMPATHETIC TRUNKS OF THE FROG

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Recently, in the somatic nerves, activity consisting of volleys of impulses not caused by known exteroceptive and interoceptive influences, and therefore called "spontaneous" has been discovered [1,2]. Investigations of this activity in the tibial nerve of the frog have shown that it is sympathetic in nature and, in M. V. Kirzon's opinion [1], it arises from the sympathetic elements of the reticular formation of the diencephalon. This "spontaneous" flow of impulses produces no change in the activity of the skeletal muscles, and it is suggested that it possesses a trophic function. Similar volleys of sympathetic impulses have been found in nerves running to the kidneys, the thyroid, and the heart [3,4-7].

A careful study of the electrical activity of the cardiac nerves has shown that it consists of several types [6-8]. In the cardiac branches of the vagus nerve of the cat, for instance, Green [6] found three types of impulses. The first type, which is inhibited during stimulation of the pressure receptors, he regarded as sympathetic activity. Impulses increasing in amplitude during stimulation of the pressure receptors he considered to be parasympathetic. Finally, he described an activity of pressure-receptor sites, without explaining what this term meant. In experiments on the cardiac branches of the vago-sympathetic trunks of the frog [7], only two types of activity were found, sympathetic and parasympathetic. Whereas parasympathetic activity may be observed only in response to reflex stimulation, sympathetic activity, in the form of tonic volleys of "spontaneous" impulses is constantly present. The same author stated that the "spontaneous" impulses disappear after division of the sympathetic chain below the jugular ganglion. In contrast to this, Sumi and Nanba [8] found "spontaneous" volleys of impulses in most of their experiments on sympathetomized frogs, in the efferent fibers of the vagus nerves. Impulses of this type were not inhibited by reflex stimulation, as the sympathetic impulses were, but, on the contrary, a sharp increase in this activity took place. Sumi and Nanba describe two types of activity ("spontaneous" and reflex), belonging only to the parasympathetic innervation.

When recording the bioelectrical activity of the cardiac branches of the vagus nerves of the frog during the study of the nervous regulation of the heart, the author also observed volleys of activity which were not produced by any known external influence. Since these volleys of impulses did not appear occasionally, but were observed constantly, it was decided to investigate as precisely as possible the localization of the origin of the volleys of "spontaneous" impulses recorded in the cardiac branches of the vago-sympathetic trunks of the frog.

EXPERIMENTAL METHOD

Experiments were carried out on the frog Rana temporaria. By means of an ac amplifier and a type MPO-2 loop oscillograph, the electrical activity of the cardiac branches of the vago-sympathetic trunks was recorded in the absence of any external influence apart from the essential operative procedures for exposing the cardiac branches. At the same time, the effect of reflexes from the urinary bladder during mechanical distention of the organ was studied on this activity. In a series of experiments, simultaneous recordings were made of the ECG in order to observe the heart rate.

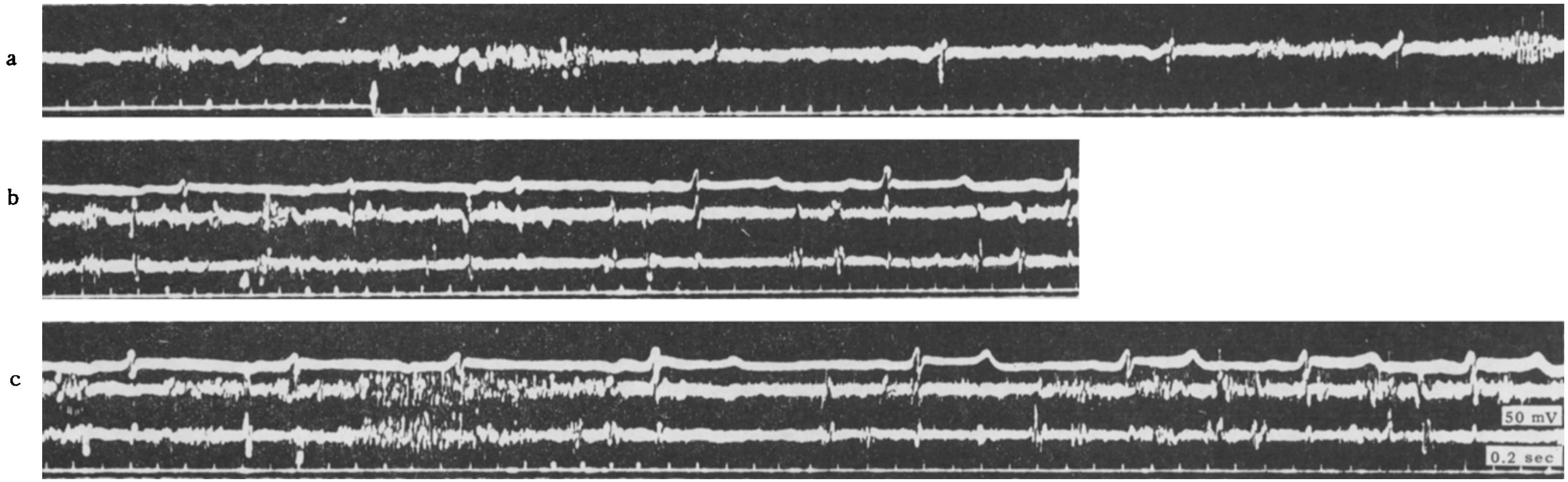

Fig. 1. Changes in electrical activity of cardiac branches of the vago-sympathetic trunks of the frog during stimulation of the urinary bladder: a) volleys of "spontaneous" activity present in the cardiac branch of the left nerve and their changes during stimulation of the urinary bladder; b) changes in the volleys of activity in the cardiac branches of the left and right vago-sympathetic trunks following introduction of 1 ml Ringer's solution into the urinary bladder; c) changes in the same activity following introduction of 2.5 ml of Ringer's solution. Significance of curves (from top to bottom) in two lower cuts (b and c); ECG; ENG of cardiac branch of left nerve; ENG of cardiac branch of right nerve; time marker (0.2 sec). The arrow points to the beginning of stimulation of the urinary bladder by introduction of Ringer's solution.

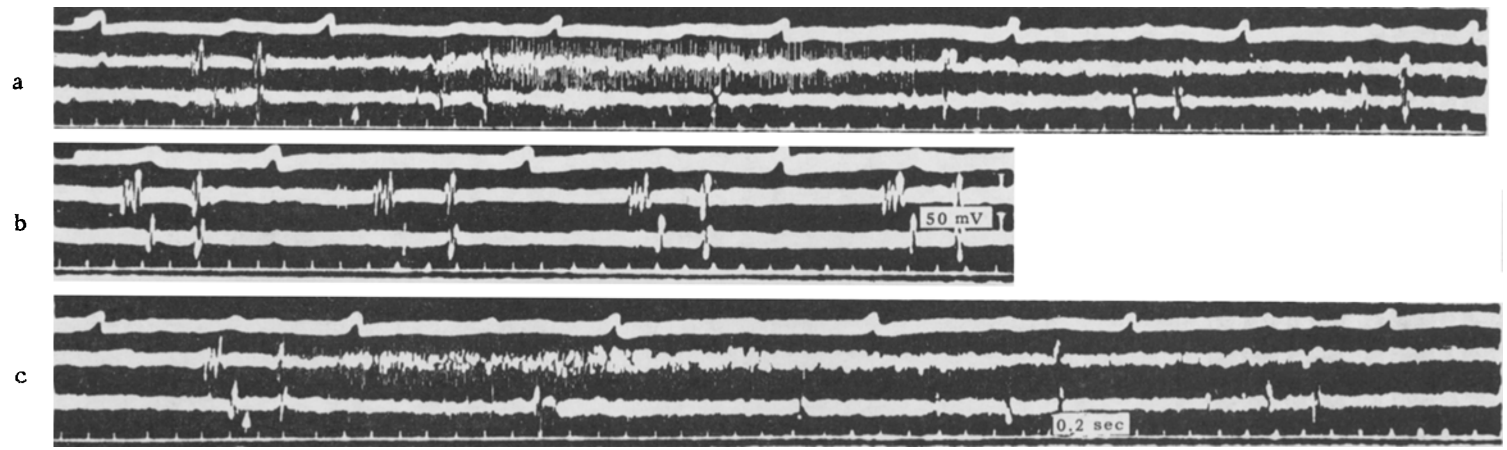

Fig. 2. Effect of excision of the first and second ganglia of the sympathetic chains on the "spontaneous" volleys and the reflex activity: a) introduction of 2.5 ml Ringer's solution into the urinary bladder; b) tracing of ENG in the absence of stimulation of the urinary bladder; b) tracing of ENG in the absence of stimulation of the urinary bladder after excision of the sympathetic ganglia; c) introduction of 3 ml of Ringer's solution into the urinary bladder after destruction of the sympathetic fibers to the heart. Significance of the curves the same as in Fig. 1.

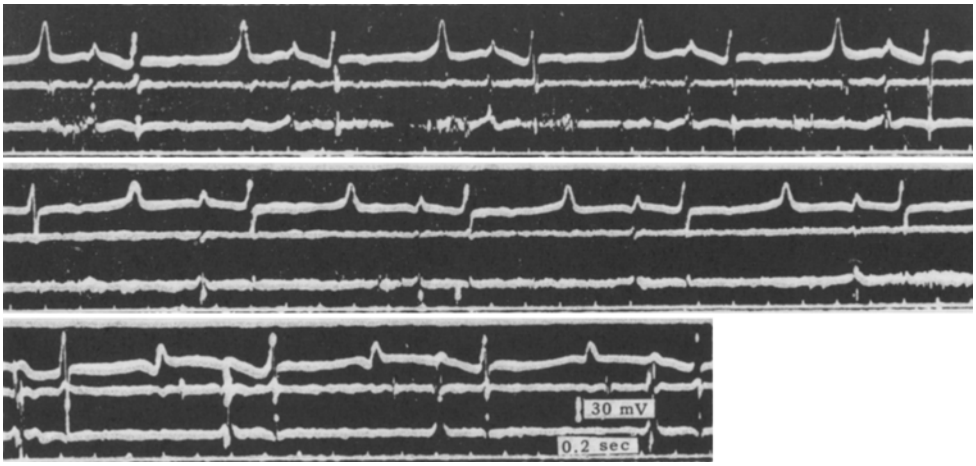

Fig. 3. Effect of destruction of the medulla and spinal cord on the electrical activity of the cardiac branches of the vago-sympathetic trunks: a) tracings of ECG and ENG before injury to the nervous system; b) changes in activity following introduction of 2 ml Ringer's solution after destruction of the medulla; c) tracings of ENG and ECG after destruction of the medulla and spinal cord. Curves in each cut (top to bottom): ECG; ENG of cardiac branch of right nerve; ENG of cardiac branch of left nerve; time marker (0.2 sec). The arrow points to the beginning of stimulation of the urinary bladder.

EXPERIMENTAL RESULTS

A recording of the electrical activity of the cardiac branch of the left vago-sympathetic trunk is shown in Fig. 1a. The cardiac branch of the right nerve was divided. Before the beginning of stimulation, volleys of impulses of constant shape and amplitude can be seen. Stimulation of the urinary bladder led to a large volley of impulses followed by inhibition of the "spontaneous" responses, despite the fact that the heart continued to beat at the same rate as before stimulation. After a short time, the "spontaneous" impulses were restored. The irregularity of the "spontaneous" activity in the two cardiac branches is also demonstrated by Figs. 1, b and c. Comparison of the "spontaneous" activity of the cardiac branches of the left and right vago-sympathetic trunk shows the great similarity to treatment, although sometimes small volleys were observed in only one branch and were absent from the other.

This result may have been due to the conditions of recording, for this was done from the whole cardiac branch which contains many shunt fibers. It is possible, however, that the activity of one branch differs slightly from the activity of the other. The strength of stimulation of the urinary bladder, which influences the size of the reflexly evoked volley, also influences the duration of inhibition of the "spontaneous" activity. A stronger stimulus (Fig. 1c) produced a larger reflex volley followed by a longer inhibition of "spontaneous" activity. A weaker stimulus (Fig. 1b) led to a shorter period of inhibition.

The next experiment showed that the "spontaneous" impulses observed originated from the sympathetic fibers of the cardiac branches of the vago-sympathetic trunk, while the reflex volleys of impulses arising in response to stimulation reflected the activity of the parasympathetic fibers. This was shown by experiments in which the sympathetic chains were divided and the first and second sympathetic ganglia were removed. The results of one such experiment are illustrated in Fig. 2. In this experiment, "spontaneous" impulses were recorded only in the cardiac branch of the right vago-sympathetic trunk. Stimulation of the urinary bladder led to a powerful volley of impulses, followed by inhibition of the "spontaneous" activity (Fig. 2a). Excision of the sympathetic ganglia completely abolished the latter (Fig. 2b). Stimulation of the urinary bladder, as before, led to the appearance of a reflex volley of parasympathetic impulses (Fig. 2c).

It was mentioned above that stimulation of the urinary bladder, activating the parasympathetic system, at the same time inhibits the impulses in the sympathetic fibers of the heart. This inhibition of sympathetic activity arises independently of excitation of the parasympathetic fibers. As shown in Fig. 3, a and b, destruction of the medulla caused hardly any change in the "spontaneous" impulses. Stimulation of the urinary bladder, now unaccompanied by excitation of the parasympathetic fibers, as before, caused inhibition of the "spontaneous" sympathetic activity. Subsequent destruction of the spinal cord led to the cessation of this activity (Fig. 3c).

The results show that "spontaneous" volleys of activity may be recorded in the cardiac branches of the vago-sympathetic trunks of the frog. These impulses are sympathetic in nature. In contrast to the observations of those authors who found the cessation of the constant volleys of impulses in the somatic nerves of the frog after section above the medulla [1,2] or in the cardiac branches of the cat after section below the hypothalamus [5], the results of these experiments showed that the "spontaneous" sympathetic activity recorded in the cardiac branches of the frog arose at lower levels of the central nervous system. Division of the sympathetic chain abolished this activity. However, the impulses were not generated in the sympathetic ganglia, but in the spinal cord, for destruction of the spinal cord when the sympathetic change remained intact was accompanied by disappearance of the "spontaneous" impulses.

It is difficult as yet to say what is the significance of these impulses. The suggestion has been made [7] that they may sometimes have a positive inotropic effect on the heart. No conclusion on this aspect of the problem can be drawn from the present observations. All that can be said is that cessation of the "spontaneous" impulses did not cause any obvious changes in the rhythm. No special experiments were carried out to determine its importance.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.