INTEGRATION OF AFFERENT INFORMATION ON GANGLION NODOSUM NEURONS

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The ganglion nodosum contains various types of neurons which receive afferent information along different fibers of the vagus nerve. It was shown in [6, 7] that information reaches cardiovascular and inspiratory neurons along myelinated fibers, whereas it reaches expiratory neurons along unmyelinated fibers of the vagus nerves. By the use of various hemodynamic and respiratory tests, neurons responding to stimulation of receptors not only of the cardiovascular or respiratory systems, but also neurons on which afferent information from both systems is integrated, have been found in the ganglion nodosum [2]. Meanwhile it is not yet clear which types of afferent nerve fibers are involved in the formation of the spike activity of these groups of neurons.

The aim of this investigation was to study the character of changes in spike activity of the various neurons of the ganglion nodosum during step by step blocking of the conduction of excitation along myelinated and unmyelinated fibers of the vagus nerves.

EXPERIMENTAL METHOD

Experiments were carried out on 35 male and female cats weighing 3-4 kg. The animals were anesthetized with pentobarbital (40 mg/kg, intraperitoneally). Spike discharges of neurons in the ganglion nodosum were recorded extracellularly by means of glass microelectrodes by the method described previously [2]. Conduction of excitation along myelinated and unmyelinated fibers was blocked by local cooling of the vagus nerve.

For this purpose the right vagus nerve was separated in the cervical division from the sympathetic nerve and that part of it which lies below the ganglion nodosum was placed on a thermode, incorporating a thermistor, after which the thermode—nerve system was carefully isolated from surrounding tissues by means of cotton wool plugs soaked with mineral oil, and rubber tubes. By means of a vacuum pump, cooling fluid from a special vessel was supplied through a system of tubes to the isolated segment of the vagus nerve, from which it was returned into another vessel. The cooling temperature of the vagus nerve was controlled by changing the rate of flow of the cooling liquid by means of a screw. The left vagus nerve was left intact. The temperature of the vagus nerve, the ECG in standard lead II, the pneumogram, and the blood pressure in the femoral artery were recorded on an M-42 myograph ("Medicor"). The recording was made on magnetic tape on an SDR-41 tape recorder ("Nihon Kohden") and on RF-3 70-mm film on an MR-4 recording camera ("Medicor"). Activity of 38 ganglion nodosum neurons was recorded and analyzed. The results were subjected to statistical analyzing using Student's test and the signs test.

EXPERIMENTAL RESULTS

Cooling the vagus nerves from 22°C to 6°C blocked conduction of excitation along myelinated fibers, and lowering the temperature to 0°C blocked conduction of excitation along unmyelinated fibers also [5, 8, 9]. On the basis of these data, spike activity of different types of ganglion nodosum neurons was studied during cooling of the vagus nerve to 6°C and to 0°C.

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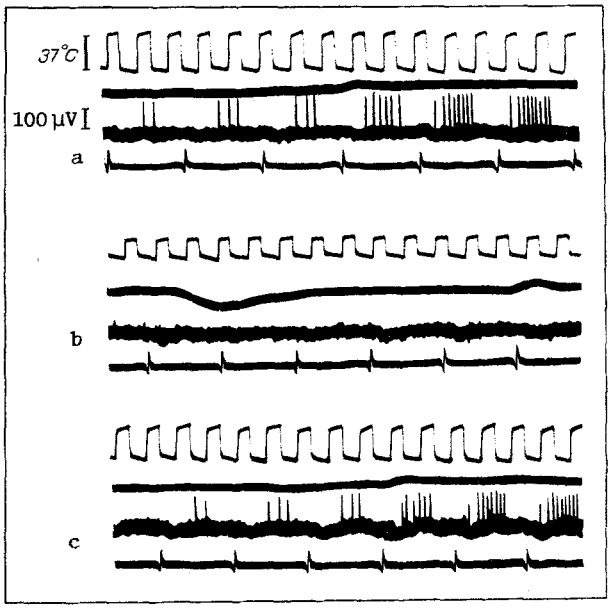

Fig. 1. Response of cardiovascular neuron to cooling of the vagus nerve: a) spontaneous activity, b) absence of neuronal activity when nerve temperature 17°C, c) recovery of neuronal activity when nerve temperature was 37°C. From top to bottom: temperature of vagus nerve, pneumogram, ECG, neuronal spike activity.

Spike activity of cardiovascular and inspiratory neurons was analyzed initially, for these are known to receive information from receptors of either the cardiovascular or the respiratory system [2, 6]. Cooling the vagus nerve to 6°C did not lead to any change in heart rate ($p < 0.01$), respiration rate ($p < 0.01$), or arterial blood pressure ($p < 0.05$). Against this background activity disappeared in five of the inspiratory neurons recorded. The same response to cooling of the vagus nerve to 6°C also was observed in three of the cardiovascular neurons recorded (Fig. 1). This fact is evidence that activity of the ganglion nodosum neurons studied, which received information from receptors of the respiratory or the cardiovascular system, is formed through the participation solely of myelinated vagus nerve fibers.

Activity of the integrative neurons of the ganglion nodosum was then analyzed: cardiopulmonary neurons, continuously firing neurons with respiratory modulation, inspiratory-expiratory and late inspiratory neurons receiving information from receptors of both the cardiovascular and the respiratory systems [2, 3]. On cooling the vagus nerve to 6°C, against the background of no change in heart rate, blood pressure, or respiration, opposite changes were observed in the activity of these groups of neurons: spike activity could be either unchanged, increased, reduced, or abolished. In some cases qualitative changes in character of the spontaneous activity were found. For instance, of 11 cardiopulmonary neurons recorded during cooling of the vagus nerve to 6°C, the firing rate of one neuron was unchanged, that of another was reduced, and activity of five neurons was absent. In four cardiopulmonary neurons the character of their spontaneous activity was modified: spike activity of two neurons became continuous with respiratory modulation, in two neurons only the cardiac component of activity was preserved, and the respiratory component disappeared (Fig. 2a, b).

Of eight continuously firing neurons with respiratory modulation recorded during cooling of the vagus nerve to 6°C, spike activity of one neuron was unchanged, that of another disappeared, and activity of a third neuron increased. Four neurons changed their initial type of activity: activity of one neuron became inspiratory-expiratory in character, and that of three neurons became cardiopulmonary.

Of six inspiratory-expiratory neurons recorded during cooling of the vagus nerve to 6°C, spike activity of two neurons was unchanged, that of one neuron was absent, and that of another neuron reduced. The original type of activity of two neurons was changed: activity of one neuron became continuous in character with respiratory modulation, that of another became irregular.

Of five late inspiratory neurons, cooling the vagus nerves to 6°C caused disappearance of the spike activity of two of them, such activity was increased in one neuron, but reduced in another two neurons.

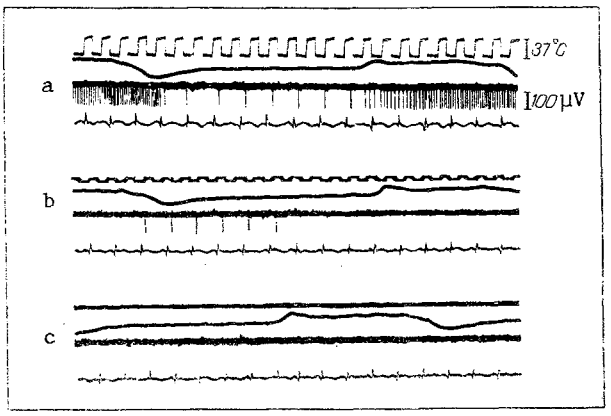

Fig. 2. Response of cardiopulmonary neuron to cooling of vagus nerve: a) spontaneous activity, b) activity of neuron when temperature of nerve was 6°C, c) absence of neuronal activity when temperature of nerve was 0°C. Legend as to Fig. 1.

Thus cooling the vagus nerve to 6°C led to disappearance of spike activity of 30% of recorded neurons receiving afferent information simultaneously from the cardiovascular and respiratory systems. These data are evidence that information reaching them along myelinated fibers is involved in the formation of the spike activity of these neurons. During cooling the vagus nerve to 6°C spike activity was preserved in 70% of recorded cardiopulmonary neurons, constantly firing neurons with respiratory modulation, and inspiratory-expiratory and late inspiratory neurons of the ganglion nodosum. Accordingly, activity of these neurons was studied during cooling of the vagus nerve to 0°C. Analysis of the data showed that under these conditions spike activity of these neurons of the ganglion nodosum disappears (Fig. 2c).

The change in the character of the spontaneous spike discharge of some neurons of the ganglion nodosum while the vagus nerve was cooled to 6°C may be connected with blocking of impulsation transmitted to these neurons along myelinated fibers and the preservation of impulsation arriving via unmyelinated fibers of the vagus nerve. This fact is evidence that some integrative neurons of the ganglion nodosum receive impulsation along two types of vagus nerve fibers simultaneously (myelinated and unmyelinated). The fact that information can be received by one neuron of the ganglion nodosum simultaneously along two types of fibers may be accounted for by the presence of synoptic connections between neurons of the ganglion nodosum [1, 4, 10].

The results are thus evidence that recorded neurons of the ganglion nodosum receiving afferent information from the cardiovascular or respiratory system receive it along myelinated fibers only. Integrative neurons, however, receiving afferent information from both cardiovascular and respiratory systems, can receive it either along fibers of one type (myelinated or unmyelinated), or simultaneously along two types of vagus nerve fibers. This conclusion suggests that integration of afferent information arriving simultaneously along different types of vagus nerve fibers may undergo integration at the level of single neurons of the ganglion nodosum.

LITERATURE CITED

1. V. I. Kirichenko, Abstracts of Proceedings of the First Scientific Conference of Junior Scientists of Stavropol' Medical Institute [in Russian], Stavropol' (1974), pp. 232-236.
2. G. I. Kositskii, S. D. Mikhailova, and T. M. Semushkina, Byull. Éksp. Biol. Med., No. 5, 24 (1982).
3. G. I. Kositskii, S. D. Mikhailova, and T. M. Semushkina, Byull. Éksp. Biol. Med., No. 12, 653 (1984).
4. Z. I. Mikheeva, Vopr. Teor. Med., **157** (1972).
5. D. N. Franz and A. Iggo, J. Physiol. (London), **199,** 319 (1968).
6. N. Mei, Exp. Brain Res., No. 11, 465 (1970).
7. N. Mei, Exp. Brain Res., No. 11, 480 (1970).
8. A. S. Paintal, J. Physiol. (London), **180,** 20 (1965).
9. W. R. Patberg, Pflügers Arch. Ges. Physiol., **398,** No. 1, 88 (1983).
10. W. Wozniak and M. Bruska, Folia Morphol. (Warsaw), **139,** No. 2, 121 (1980).