HEMODYNAMIC CHANGES DURING STIMULATION OF STRUCTURES OF THE BULBAR CARDIOVASCULAR CENTER BY ACETYLCHOLINE

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The effect of microinjection of acetylcholine (AC) into the nucleus of the tractus solitarius, the nucleus cuneatus, and nucleus ambiguus of anesthetized cats on cardiovascular activity was investigated. Marked depressor responses were observed to stimulation of the n. cuneatus and n. ambiguus. These responses were abolished by vagotomy or by atropinization of the animal. Injection of AC into the nucleus of the tractus solitarius was not accompanied by the development of such distinct or regular hemodynamic responses. In vagotomized or atropinized cats a pressor response developed after injection of AC into the nucleus of the tractus solitarius.

Modern views on the functional organization of the bulbar vasomotor center are based on investigations carried out mainly by methods of local destruction, division, and electrical stimulation [3, 4, 7]. The interpretation of the results obtained by these methods requires caution because of the presence of anatomical and functional connections in the brain stem between nervous structures controlling the functions of the circulation, respiration, and somatic activity [4, 7].

The sensitivity of many neurons of the brain stem to acetylcholine (AC) is high, and in particular it has a marked effect on cardiovascular neurons [2, 6, 11, 12].

Since information on the functional properties of several bulbar structures, especially those in which impulses are presumed to relay from the sino-aortic reflexogenic zone (the nucleus of the tractus solitarius, nucleus cuneatus, and nucleus ambiguus), is totally inadequate, an attempt was made to add to it by studying the character of the hemodynamic changes arising during stimulation of these structures by AC.

EXPERIMENTAL METHOD

Experiments were carried out on cats anesthetized with chloralose (50 mg/kg) and pentobarbital (10 mg/kg), injected intraperitoneally. The animal's head was fixed in a type SÉ Zh-2 stereotaxic apparatus at an angle of 45° to the horizontal. The position of the structures to be tested in space was determined by counting from the obex. To inject AC into the medullary structures a syringe with micrometer attachment to the plunger was used, and 0.5-1.0 μg acetylcholine chloride was injected into each point. The same volume of 0.9% sodium chloride solution was injected into the same points for control purposes.

The systemic arterial pressure was recorded in the femoral artery by means of a cannula connected to an electrical manometer. The minute blood volume was determined by the thermodilution method in the modification developed in the Department of Physiology of the Circulation, A. A. Bogomolets Institute of Physiology, Academy of Sciences of the Ukrainian SSR, and the pulse rate was counted from the fluctuations in pulse pressure. In some experiments bilateral vagotomy or atropinization of the animal (0.5 mg/kg atropine intravenously) was performed. The localization of the needle of the microinjector was verified in each experiment by histological examination of brain sections.

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TABLE 1. Changes in Parameters of Hemodynamics during AC Stimulation of Structures of the Bulbar Cardiovascular Center

Hemodynamic index	Statistical index	N. cuneatus		N. ambiguus		N. tracti solitarii	
		initial	at height of response	initial	at height of response	initial	at height of response
Systemic arterial pressure (in mm Hg)	n	18	18	12	12	26	26
	M	148,30	132,70	148,00	129,00	131,40	122,80
	$\pm m$	4,02	6,60	4,90	3,70	5,10	6,60
	P		0,05		0,01		0,5
Heart rate	M	226,80	216,00	267,00	246,00	216,00	210,50
	$\pm m$	3,02	6,04	5,20	7,30	10,50	8,70
	P		0,1		0,02		0,2
Minute blood volume (in ml)	M	249,40	216,16	256,20	223,20	241,50	233,10
	$\pm m$	7,63	11,10	14,20	5,80	10,30	12,50
	P		0,05		0,05		0,2
Systolic blood volume (in ml)	M	1,22	0,99	0,98	0,76	1,18	1,13
	$\pm m$	0,07	0,10	0,10	0,12	0,06	0,06
	P	0,5			0,1		0,5
Cardiac index (in $ml/m^2/min$)	M	0,84	0,74	0,88	0,76	0,83	0,79
	$\pm m$	0,03	0,04	0,02	0,03	0,03	0,04
	P		0,05		0,01		0,5
Systolic index (in ml/m^2)	M	3,81	3,34	3,30	3,00	4,10	3,89
	$\pm m$	0,14	0,11	0,15	0,16	0,15	0,26
	P		0,5		0,2		0,5
Working index of left ventricle (in $kg \cdot m/m^2/min$)	M	1,68	1,35	1,68	1,30	1,48	1,33
	$\pm m$	0,07	0,08	0,08	0,10	0,09	0,10
	P		0,01		0,02		0,5
Working stroke index of left ventricle (in $kg \cdot m/m^2$)	M	7,67	5,84	6,25	5,70	6,89	6,42
	$\pm m$	0,62	0,41	0,70	0,29	0,55	0,65
	P		0,02		0,05		0,5
Total peripheral resistance (in dynes $\cdot sec \cdot cm^{-5}$)	M	48600,00	50420,00	46200,00	46200,00	43440,00	42100,00
	$\pm m$	2320,00	3690,00	4310,00	7820,00	2550,00	1280,00
	P		0,5		0,2		0,5

EXPERIMENTAL RESULTS

When AC was injected into the n. cuneatus, n. ambiguus, and n. tracti solitarii, hemodynamic responses of varied severity developed, in agreement with results showing the irregular distribution of neurons sensitive to AC in the medulla [11]. The strongest responses developed to injection of AC into n. cuneatus and n. ambiguus (Table 1).

A decrease in the minute and systolic blood volumes during stimulation of these structures was combined in most experiments with a decrease in the heart rate.

The depressor responses developing after injection of AC into n. cuneatus and n. ambiguus were blocked by bilateral vagotomy or by atropinization of the animal, blocking muscarine-like cholinergic peripheral systems. Presumably the developing hemodynamic responses were linked to a certain extent with activation of structures belonging to the parasympathetic division of the autonomic nervous system.

Injection of AC into n. tracti solitarii was not accompanied by any marked hemodynamic reactions (Table 1) even though this nucleus is regarded as the principal region of entry of afferent impulses from the main reflexogenic zones of the cardiovascular system into the medulla [9]. This may be due to the very small number of acetylcholine-sensitive neurons in n. tracti solitarii [14]. A pressor response developed in the vagotomized or atropinized animals after injection of AC into n. tracti solitarii.

The doses of AC used in these experiments were small, so that its penetration into the systemic circulation was unlikely to have occurred in practice. For this reason the writers consider that the hemodynamic responses which developed were mainly attributable to the action of AC on medullary structures concerned with the regulation of activity of the cardiovascular system.

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