

# Effect of Selective Vagotomy on Inotropic and Chronotropic Heart Function in Rats

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Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 128, No. 11, pp. 497-499, November, 1999  
Original article submitted April 22, 1999

Right-sided vagotomy induced more rapid and pronounced changes in chronotropic indices, while left-sided vagotomy predominantly affected stroke volume. Right-sided, left-sided, and bilateral vagotomy induced similar changes in the variational pulsogram.

**Key Words:** *vagus nerve; heart; stroke volume; heart rhythm variability; rat*

Extracardiac regulation of the cardiac function is provided by sympathetic and parasympathetic influences which are considered as antagonistic, synergic, and compensatory [2,7,9]. Heart response to removal of the parasympathetic influences is species-specific [3, 6]. In dogs, the right vagus nerve (VN) regulates the chronotropic, while the left VN controls the inotropic function of the heart [4]. It can be assumed that contraction force and heart rate are regulated by different mechanisms [5]. Therefore, it is of interest to study the tonic influence of contralateral VN on the inotropic and chronotropic heart functions. We studied the dynamics of stroke volume (SV) and parameters of a variational pulsogram after selective vagotomy in rats.

## MATERIALS AND METHODS

Experiments were carried out on 20-week-old outbred albino rats ( $n=24$ ) anesthetized with intraperitoneal urethan (800 mg/kg, 25% solution). Vagotomy was performed after fixation of the animal on the operation table and VN preparation. In group 1, the right and left VN were cut consecutively with a 60-min interval. In group 2, first the left and then the right VN were cut. In group 3 simultaneous bilateral vagotomy was performed. ECG and differential rheogram were recorded throughout the experiment to analyze heart activity.

The data were processed with a Conan<sub>m</sub>-2.0 electrophysiological set. The variational pulsogram was processed as described elsewhere [1], SV was calculated by the formula [8].

## RESULTS

Right-sided vagotomy caused a transient but significant increase in HR and cardiac output (CO) (Table 1). The most pronounced changes in these indices were observed for the first 5 min. During this period SV showed no significant changes, but then SV and HR decreased.

On the contrary, left-sided vagotomy significantly changed SV and only little affected HR (Table 2). SV decreased by 9% for the first minute, then increased, and after 5 min exceeded the initial value by 12.4%. It did not return to the baseline within 60 min, while HR decreased after 30 min ( $p<0.01$ ). Both right-sided and left-sided vagotomy increased the mode amplitude and stress index and decreased the variation amplitude (Table 1, 2). At the same time, the dynamics of SV and HR were different which testifies to the specific effects of the right and left VN on contraction force and HR.

Right-sided vagotomy performed after transection of the left VN increased SV. The increase was most pronounced after 5 min, then SV returned to the initial level (Table 2). HR increased by 3.7% during the first 5 min, then decreased, and after 60 min was 11% below the initial value.

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TABLE 1. Dynamics of Heart Function Indices in Adult Rats after Right-Sided Vagotomy Followed by Left-Sided ( $M \pm m$ ,  $n=9$ )

Indices	Baseline	Right-sided vagotomy, min				Left-sided vagotomy, min			
		1	5	30	60	1	5	30	60
SV, ml	0.1192±0.0051	0.1152±0.0023	0.1204±0.0051	0.1151±0.0050	0.1016±0.0028*	0.0987±0.0039	0.1359±0.0073**	0.1045±0.0078	0.1018±0.0079
HR, beats/min	368±7.84	392±9.43	399±8.81*	367±11.24	350±8.62	371±7.48	385±8.35*	362±7.46	356±6.75
CO, ml/min	43.63±1.07	45.06±0.89	47.81±1.16*	41.97±1.60	35.43±0.95**	36.43±0.97	51.87±1.78***	37.67±2.76	36.19±2.83
Mode amplitude, %	36.43±1.98	39.63±4.09	58.84±4.13**	48.38±4.13	39.14±2.29	41.83±3.61	60.44±3.74**	49.17±3.17*	47.78±3.55
Variation, msec	5.00±0.24	7.00±0.94	4.00±0.00*	5.00±0.33	5.20±0.15	5.40±0.38	4.60±0.18*	5.40±0.30	5.00±0.24
$\Sigma$ , arb. units	1.10±0.05	1.31±0.07*	1.11±0.03	1.09±0.05	1.07±0.03	1.22±0.09	1.21±0.06	1.24±0.11	1.20±0.09
Stress index, arb. units	31200±2408	28000±3842	48400±2797**	36100±1134	32200±2291	27600±3043	42800±3081	31800±4252	32400±4083

Note. Here and in Tables 2 and 3: \* $p<0.05$ ; \*\* $p<0.01$ ; \*\*\* $p<0.001$  in comparison with the baseline

TABLE 2. Dynamics of Heart Function Indices in Adult Rats after Left-Sided Vagotomy Followed by Right-Sided ( $M \pm m$ ,  $n=8$ )

Indices	Baseline	Right-sided vagotomy, min				Left-sided vagotomy, min			
		1	5	30	60	1	5	30	60
SV, ml	0.1319±0.0039	0.1201±0.0058	0.1505±0.0060*	0.1439±0.0119	0.1477±0.0114	0.1436±0.0110	0.1611±0.0082	0.1438±0.0073	0.1443±0.0082
HR, beats/min	328±2.02	322±2.61*	332±4.35	309±4.94**	300±5.17**	306±5.73	311±5.61	298±7.74	292±8.28
CO, ml/min	43.37±1.26	38.66±1.90	49.97±2.07*	44.28±3.49	44.34±3.46	44.02±3.54	49.98±2.49	42.85±2.38	42.02±2.40
Mode amplitude, %	45.85±6.60	32.99±2.69	59.13±4.20	41.78±4.02	40.56±4.92	36.49±3.71	50.51±1.84	43.75±2.77	37.66±1.57
Variation, msec	5.83±0.27	7.33±0.58	4.83±0.52	6.50±0.54	6.17±0.35	7.67±0.80	5.33±0.43	6.33±0.48	6.5±0.54
$\Sigma$ , arb. units	1.85±0.32	1.96±0.30	1.55±0.11	1.37±0.10	1.45±0.10	1.73±0.14	1.69±0.10	1.58±0.15	1.71±0.15
Stress index, arb. units	21900±5058	14200±2262	33200±4066	22100±2009	20800±1474	19300±2492	25600±2404	21400±1733	18100±1899

**TABLE 3.** Dynamics of Heart Function Indices in Adult Rats after Simultaneous Bilateral Vagotomy ( $M \pm m$ ,  $n=7$ )

Indices	Baseline	Bilateral vagotomy, min			
		1	5	30	60
SV, ml	0.1301 $\pm$ 0.0054	0.1466 $\pm$ 0.0046*	0.1474 $\pm$ 0.0047*	0.1330 $\pm$ 0.0037	0.1347 $\pm$ 0.0013
HR, beats/min	360 $\pm$ 10.86	385 $\pm$ 6.14*	369 $\pm$ 7.19	329 $\pm$ 15.59	319 $\pm$ 12.52*
CO, ml/min	46.54 $\pm$ 0.96	55.91 $\pm$ 1.06***	54.32 $\pm$ 1.49**	43.84 $\pm$ 2.54	43.59 $\pm$ 1.62
Mode amplitude, %	34.89 $\pm$ 4.12	42.24 $\pm$ 7.11	54.26 $\pm$ 2.47**	41.74 $\pm$ 3.44	40.63 $\pm$ 2.37
Variation, msec	6.00 $\pm$ 0.46	6.60 $\pm$ 0.87	4.40 $\pm$ 0.21*	5.00 $\pm$ 0.27	5.40 $\pm$ 0.43
$\Sigma$ , arb. units	1.19 $\pm$ 0.10	1.34 $\pm$ 0.18	1.26 $\pm$ 0.10	1.13 $\pm$ 0.11	1.28 $\pm$ 0.11
Stress index, arb. units	22260 $\pm$ 3499	27280 $\pm$ 5800	34200 $\pm$ 4045*	24160 $\pm$ 3794	22660 $\pm$ 3591

Left-sided vagotomy performed after right-sided vagotomy slightly decreased SV for a short period (Table 1). After 5 min SV sharply (by 25%) increased and then gradually returned to the baseline. These changes were accompanied by a transient increase ( $p < 0.05$ ) and rapid restoration of HR.

Simultaneous bilateral vagotomy significantly increased SV and HR during the first minute (Table 3). SV continued to increase for the next 5 min, while HR and CO started to decline. After 60 min SV decreased but remained above the baseline, while HR became below the initial values.

These data suggest that right-sided vagotomy exerts a pronounced and rapid effect on rat heart chronotropic function while left-sided vagotomy predominantly affects SV. Unilateral and bilateral vagotomy similarly changed parameters of variational pulsogram. The vagotomy-induced decrease in the variation amplitude and the increase in the mode amplitude and stress index attest to reduced activity of the parasympathetic regulation of cardiac activity. Our data confirm that the right VN predominantly modulates the chrono-

tropic, while the left VN — inotropic function of the heart. They also indicate that extracardiac influences more rapidly affect HR than contraction force.

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