PHYSIOLOGY

Asymmetrical Effects of Vagus Nerves on Functional Parameters of Rat Heart in Postnatal Ontogeny

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Significant age-related peculiarities in the dynamics of stroke volume and parameters of variational pulsogram are revealed in bilaterally vagotomized in rats. Asymmetry in vagal influences on cardiac function appear during puberty. Right-sided vagotomy predominantly affects variability of the cardiac rhythm, while left-sided vagotomy mostly affects the force of heart contractions.

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

According to current views, age-related peculiarities of cardiac function are related to the development of sympathetic and parasympathetic innervation of the heart. It is well established that parasympathetic cardiotropic influences develop earlier than sympathetic regulation [5,13]. Some researchers believe that the age-related changes in cardiac activity result from potentiation of parasympathetic influences and weakening of the sympathetic control [1,2,7]. It was also demonstrated that regulation of the heart rate (HR) appears earlier than the regulation of myocardial contractility [10]. The parasympathetic regulation of the heart is species-specific [11]. In some species cardiotonic influences of vagus nerves (VN) are disputed [6].

Our aim was to study the age-related peculiarities in the dynamics of stroke volume (SV), HR, cardiac output (CO), and indices of heart rhythm variability in rats subjected to selective unilateral vagotomy at various stages of postnatal ontogeny.

MATERIALS AND METHODS

The study was carried out on 67 random-bred Wistar rats aging 14, 42, 56, and 120 days. The rats were anesthetized with intraperitoneal urethane (800 mg/kg, 25% solution). Vagotomy was performed after fixation of the animal on the operation table and preparation of VN. Right- and left-sided vagotomy was performed in groups 1 and 2, respectively. To analyze cardiac activity, ECG and differential rheogram were continuously recorded for 60 min. The data were processed with a Conan$_m$-2.0 electrophysiological set. Variational pulsogram was processed by the method of R. M. Baevskii [4]. SV was calculated by the formula [12] with some modifications [3,9].

RESULTS

Age-related peculiarities in the heart reaction to vagotomy were revealed. In 14-day-old rats, right-sided vagotomy produced no changes in SV during the entire experimental period (Fig. 1, *a*, *b*); HR slightly decreased (by 7.3%) after 60 min, while CO decreased significantly ($p<0.01$).

Significant increase in SV and HR ($p<0.05$) was observed 5 min after right-sided vagotomy in 42-day-old (prepubertal) rats (Fig. 1, *c*, *d*). SV did not significantly change after 60 min, while HR significantly decreased ($p<0.001$). CO remained elevated by 8.1%.

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In 56-day-old (pubertal) rats, right-sided vagotomy produced a rapid (within 1 min) and significant decrease in SV ($p<0.05$) with simultaneous pronounced rise of HR from 411±9.85 to 441±3.79 bpm ($p<0.05$, Fig. 2, *a*, *b*). SV returned to baseline after 5 min and significantly surpassed it by the end of the experiment against the background HR drop by 5.1% ($p<0.01$).

In mature rats, HR significantly increased by 8.4% (from 368±7.84 bpm, $p<0.05$) 5 min after right-sided vagotomy, while SV remained practically unchanged (Fig. 2, *c*, *d*). An increase in mode amplitude and strain index and a decrease in variational range coincided with maximum HR. Sixty minutes after right-sided vagotomy, HR returned to the initial level (Fig. 2, *d*), while SV decreased by 14.8% ($p<0.05$). The parameters reflecting activity of sympathetic and parasympathetic systems (mode amplitude and variational range) remained elevated after 60 min, although these changes were insignificant.

In 14-day-old rats, left-sided vagotomy produced no significant changes in HR after 5 min (Fig. 1, *b*), while after 30 min this parameter decreased by 7% ($p<0.05$).

In 42-day-old rats, left-sided vagotomy increased HR by 3.5% after 5 min (Fig. 1, *d*), but after 60 min HR significantly decreased by 10.6% ($p<0.05$).

In 56-day-old rats, left-sided vagotomy produced a significant decrease in HR by 2% ($p<0.05$) and 14.7% ($p<0.001$) after 5 and 60 min, respectively (Fig. 2, *b*).

In all examined age groups, left-sided vagotomy gradually increased SV and decreased HR, but only in 42-day-old rats this increase was significant after 30 min ($p<0.05$). In other age groups these changes were less pronounced.

In 120-day-old mature rats, left-sided vagotomy produced a significant increase in SV from 0.1319±0.0039 to 0.1505±0.0060 ml ($p<0.05$) after 5 min, while HR remained unchanged (Fig. 2, *c*, *d*). At the end of the experiment HR decreased ($p<0.01$), while

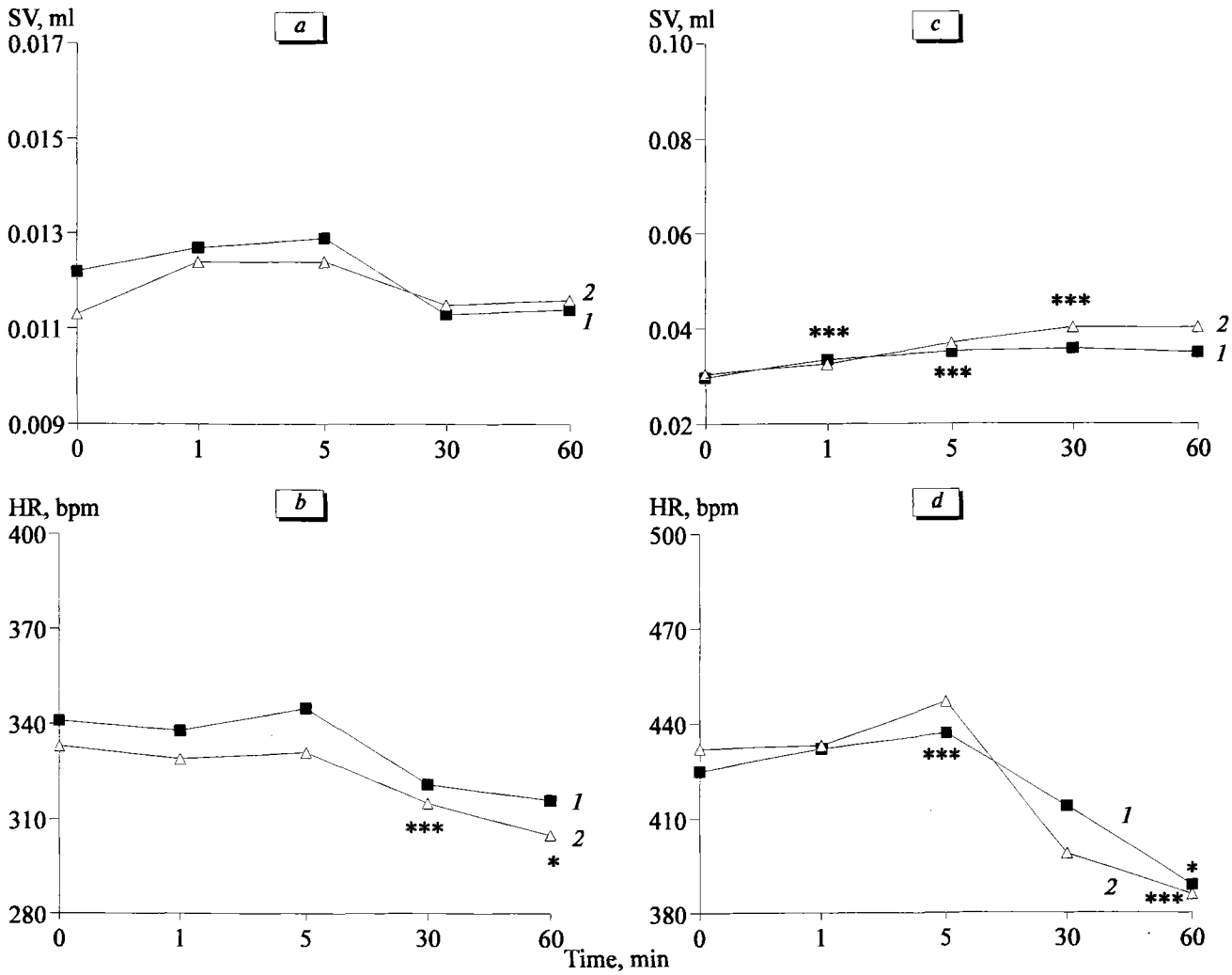

Fig. 1. Dynamics of stroke volume (SV) and HR in 14- (*a*, *b*) and 42-day-old (*c*, *d*) rats after selective right- (*1*) and left-sided (*2*) vagotomy.

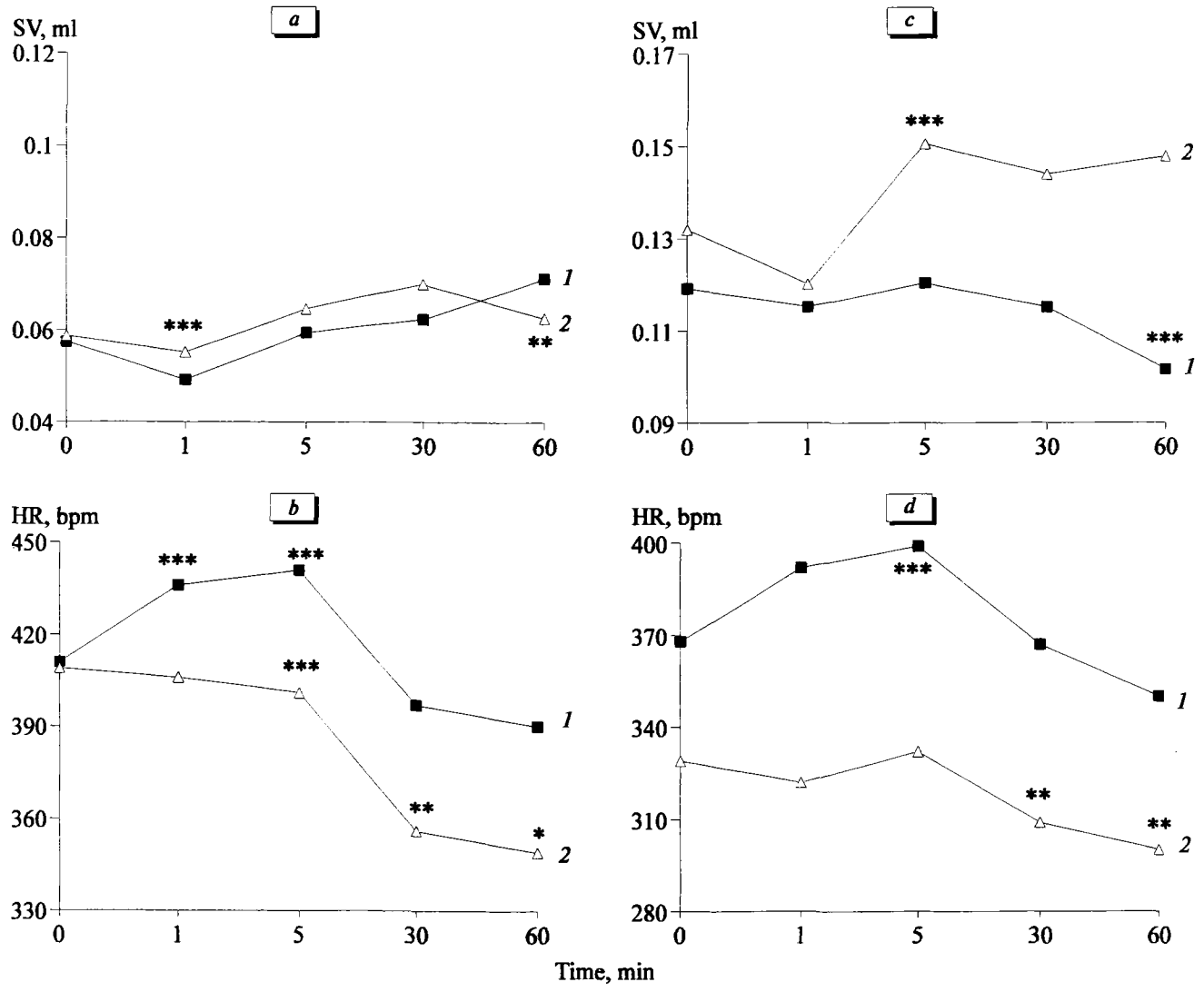

Fig. 2. Dynamics of stroke volume (SV) and HR in 56-day-old (*a*, *b*) and 120-day-old (*c*, *d*) rats after selective right- (*1*) and left-sided (*2*) vagotomy.

SV surpassed the baseline by 12%. At this period, mode amplitude, strain index, and Σ decreased, while variational range increased. The observed dynamics of parameters of variational pulsogram after left-sided vagotomy indicates enhancement of the parasympathetic control. Presumably, activation of the parasympathetic system is compensatory and manifested in enhanced activity in intact right VN.

Variational range decreased in all age groups 5 min after left-sided vagotomy despite nonuniform changes in SV and HR, which attests to weakening of the parasympathetic control. There was no asymmetry in the effects of right- and left-sided vagotomy in 14- and 42-day-old rats. In suckling rats unilateral right- or left-sided vagotomy produced no increase in SV and HR, while in 42-day-old rats such intervention markedly increased both these parameters. Similar positive dynamics of the examined cardiac indices in vagotomized rats is characteristic of prepubertal animals only. Asymmetry in parasympathetic influences on chronotropic and inotropic cardiac activity appears in 56-day-old (mature) rats. Experiments with unilateral vagotomy showed that the right VN affects predominantly HR, while SV is mainly regulated via the left VN. Our experiments demonstrated essential age-related peculiarities in the vagal regulation of cardiac function.

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