Body Surface Potential Mapping During Heart Hypertrophy Development in Infant Rats

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Abstract. *Body surface potential mapping (BSPM) was performed in Wistar rats and in rats with inherited stress-induced arterial hypertension (ISIAH) at the age of 1, 7, 17 and 30 days. When analyzing isopotential maps of rats 3 phases of the ventricular depolarization were defined, and significant changes in durations of these phases in Wistar and ISIAH rats during early postnatal ontogenesis were determined. It was revealed that the duration of the ventricular depolarization in Wistar rats increased gradually from the 1st to the 30th day of postnatal ontogenesis and mostly on account of the middle phase. Duration of the ventricular depolarization in 1 day aged ISIAH rats was significantly larger than in Wistar rats of the same age, but it didn't change during the 1st month of postnatal ontogenesis and moreover it paradoxically decreased from the 1st to 17th day on account of the initial and terminal phases. For the first time significant changes in the durations of the ventricular depolarization and its phases between normotensive and hypertensive rats of the same ages revealed by the using BSPM may be considered as initial markers of the ventricular hypertrophy that developed in ISIAH rats during the early postnatal ontogenesis.*

Keywords: heart hypertrophy, depolarization, rats, ontogenesis

1. Introduction

Early postnatal ontogenesis is a period of powerful morphological and physiological changes of an organism. These changes are more expressed in immature born mammals, such as rats and murine rodents, and they affect all systems, including cardiovascular system.

During early postnatal ontogenesis of normotensive rats a relative prevalence of heart right ventricle disappears [1], number and sizes of cardiomyocytes increase [2], ion channel expression and function change [3]. All these factors affect an electrical heart activity of rats.

Rats with inherited stress-induced arterial hypertension (ISIAH) are characterized by the pronounced genetic predisposition to the development of arterial hypertension [4] that causes myocardial hypertrophy [5]. Previously it was shown that arterial pressure of 1-month old ISIAH rats was significantly higher in comparison with Wistar rats reaching the "hypertensive level" (> 150 mm Hg) to the age of 3 months, but this hypertension development didn't cause any ECG changes typical for myocardial hypertrophy in 3-months old ISIAH rats [4].

The goal of this work is to investigate age-specific alterations of heart ventricular depolarization in normotensive rats and in ISIAH rats to establish whether some signs of the ventricular hypertrophy caused by inherited arterial hypertension during postnatal ontogenesis are "visible" even at birth.

2. Subject and Methods

The study was conducted according to the local ethic committee of the Laboratory of comparative cardiology of the Komi Science Centre, Ural Division, Russian Academy of Sciences and to the principles of the humane relation to animals as provided by clauses of

«The European Convention for the Protection of Vertebrate Animals used for Experimental and Other Scientific Purposes» (ETS N 123 from 18.03.1986).

Body surface potential mapping (BSPM) was done in Wistar and ISIAH rats at the age of 1 (n = 29 and n = 12, respectively), 7 (n = 26 and n = 10, respectively), 17 (n = 18 and n = 10, respectively) and 30 (n = 11 and n = 9, respectively) days of postnatal ontogenesis. Animals were anaesthetized with ether (inhalation narcosis) or urethane (1.5 g/kg, im). Electrophysiological data were obtained from the anaesthetized rats lying on the back.

Cardioelectric potentials were recorded from 32 subcutaneous needle electrodes uniformly distributed on an animal chest from the neck base to the last costa in 4 vertical lines. Electrocardiograms (ECGs) from limb leads were recorded synchronously with ECGs from the body surface. All time values were represented relatively to the RII-peak. Electrical heart activity was analyzed during heart ventricular depolarization by the spatial and temporal parameters of body surface isopotential maps. Data were given as mean ± standard deviation.

3. Results

It was shown that electrical heart field during ventricular depolarization was formed on the body surface of Wistar and ISIAH rats aged from 1 to 30 days on 7-10 ms before the RII-peak. The zones of positive and negative cardiopotentials changed their locations twice during ventricular depolarization in all rats, and three phases of depolarization were detected by the beginning and ending of these two inversions [6]. After the first inversion of mutual cardiopotentials' distribution the zone of negative cardioelectric potentials was situated on the cranial, the area of positive one – on the caudal part of the chest. This distribution of cardiopotentials was retained during the middle phase of ventricular depolarization. During the terminal phase of depolarization the area of electronegativity was situated on the caudal, the zone electropositivity – on the cranial surface of the chest. This localization of cardioelectric potentials on the body surface didn't change till the end of ventricular depolarization.

When analyzing body surface potential maps of Wistar and ISIAH rats significant changes in durations of ventricular depolarization phases were determined (Fig. 1). Duration of the initial phase of depolarization didn't change with age in Wistar rats (Fig. 1a), but in ISIAH rats (Fig. 1b) it slightly increased with the age from 1 to 7 days from 6.83 ± 1.62 ms to 7.3 ± 1.92 ms, then it significantly decreased to the age of 17 days to 4.8 ± 0.93 ms ($p < 0.05$), and then increased to the age of 30 days to 6.83 ± 2.02 ms ($p < 0.05$). Duration of the middle phase in Wistar rats significantly increased with the age from 1 to 30 days from 5.67 ± 1.47 ms to 10.36 ± 1.06 ms ($p < 0.05$), but in ISIAH rats it didn't change with age. Duration of the terminal phase in Wistar rats slightly increased with the age from 1 to 30 days from 1.86 ± 0.81 ms to 2.77 ± 1.36 ms, while in ISIAH rats it decreased with age from 1 to 17 days from 6.15 ± 2.1 ms to 3.68 ± 1.07 ms and then it increased to the age of 30 days to 5.72 ± 1.51 ms ($p < 0.05$).

It was revealed that the duration of the ventricular depolarization in Wistar rats increased gradually from the 1st to the 30th day of postnatal ontogenesis and mostly on account of the middle phase. Duration of the ventricular depolarization in 1 day aged ISIAH rats was significantly larger than in Wistar rats of the same age, but it didn't change during the 1st month of postnatal ontogenesis and moreover it paradoxically decreased from the 1st to 17th day on account of the initial and terminal phases.

4. Discussion

It was revealed that the spatial dynamics of body surface cardioelectric field of ISIAH rats during ventricular depolarization and repolarization didn't change with age and was similar to that of newborn Wistar rats [7]. When analyzing the temporal dynamics of body surface cardioelectric field it was shown that durations of depolarization phases changed with age in different ways. The decreasing of the initial and terminal phases of depolarization with age from 1 to 17 days in ISIAH rats might be the evidence of a gradual disappearance of the relative heart hypertrophy that caused after the birth till 10-17 days of postnatal ontogenesis [1]. The increasing of these parameters to the age of 30 days might be the evidence of the beginning of the left ventricular hypertrophy development. This hypertrophy is typical for ISIAH rats [4]. In normotensive Wistar rats changes in durations of depolarization phases during early postnatal ontogenesis differed from those in ISIAH rats – the significant increase of duration of the middle phase was detected, and this increase was resulted in the increase of duration of the whole depolarization.

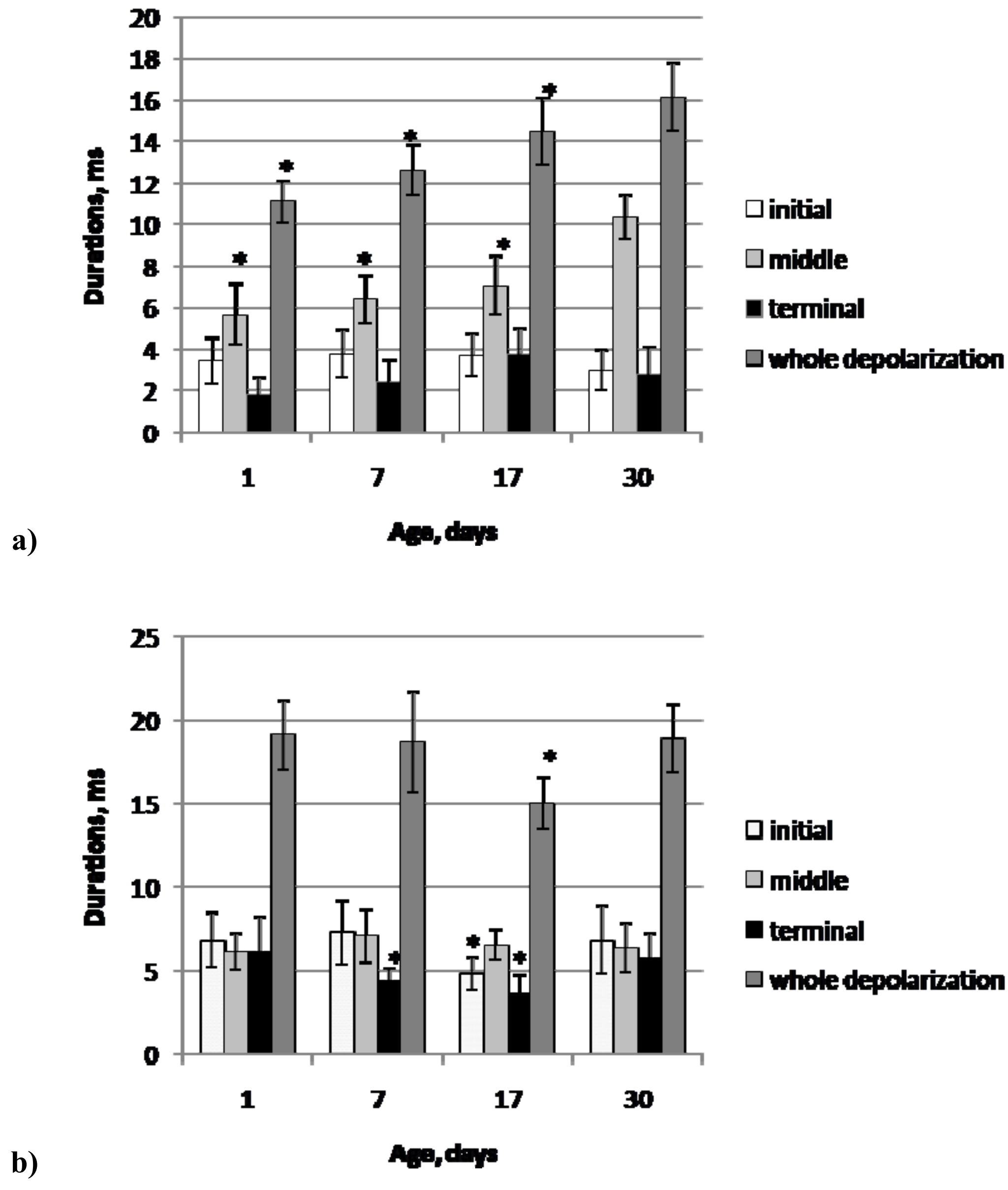

Fig. 1. Durations of ventricular depolarization phases detected by BSPM in Wistar (a) and ISIAH (b) rats of different ages. * - $p<0.05$ in comparison with rats at the age of 30 days.

For the first time significant changes in the durations of the ventricular depolarization and its phases between normotensive and hypertensive rats of the same ages revealed by the using BSPM may be considered as initial markers of the ventricular hypertrophy that developed in ISIAH rats during the early postnatal ontogenesis.

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