CHANGES IN PHASE CHARACTERISTICS OF ACTIVITY OF THE VASCULAR SYSTEM REVEALED BY RHEOGRAPHY IN DOGS AT DIFFERENT AGE PERIODS

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Rheograms of puppies during early postnatal development are characterized by maximal amplitude, maximal rate of rise of the curve in the phase of rapid filling, maximal mean rate of fall of the catacrotic wave, and total absence of the dicrotic wave. The first three indices fall sharply in puppies by the age of 12 days, when a small dicrotic wave appears on the rheogram from the forelimbs. In puppies aged 16-23 days a dicrotic wave also appears in the rheogram from the hind limbs.

Laboratory investigations have shown that at an early age sympathico-adrenergic regulatory mechanisms are predominant, while with the appearance of antigravity responses vago-cholinergic mechanisms of regulation of cardiovascular activity appear and gradually become more firmly established [1-5, 7].

The object of the investigation described below was to study the blood volume of the skeletal muscles and to compare it with the cardiac activity in dogs at different age periods by the method of impedance plethysmography (rheography).

EXPERIMENTAL METHOD

Longitudinal rheograms of the fore- and hind limbs, their first derivatives (velocity curves), and the ECG in lead II were recorded. The 4RG-1A rheograph designed by the Experimental Instruments Workshops of the Academy of Medical Sciences of the USSR (differential RC-circuit with time constant 0.005 sec) and ÉLKAR-6 electrocardiograph, with time constant 1.5 sec and transmission band 0.2-70 Hz, and with speeds of 50 and 100 mm/sec, were used for the recording. The rheographic electrodes were tin disks each with an area of 2 cm^2. The interelectrode distance was constant at 1.5 cm.

The duration (Fig. 1) of the phases of rapid filling (a), slow filling (b), catacrotic wave (D), the time of one complete pulse wave (T), the heart rate, and the amplitudes of the curve in ohms (R_2) were calculated. The rate of rise of the curve in the phase of rapid filling in ohms per second (V_a) and the rate of rise of the curve in the phase of slow filling in ohms per second (V_b) also were calculated. The mean rate of fall of the catacrotic wave (V_d) or the relative index β were calculated by the equation

$$Vd = \frac{R_2 \times P}{tk},$$

where R_2 is the amplitude of the curve (in ohms); P, the heart rate; and t_c, the duration of the catacrotic wave (in sec). The temporal indices also were calculated as percentages of the total duration of the pulse wave.

The investigation was carried out on 26 puppies at rest, aged from 4 days to 3 months. Four age groups were distinguished on the basis of the laboratory results and results of the present investigation:

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TABLE 1. Indices of Rheograms of Fore- and Hind Limbs of Dogs at Different Ages (M ± m)

Age	Limb	*a*		*b*		*D*	
		Absolute value (in sec)	in %	Absolute value (in sec)	in %	Absolute value (in sec)	in %
4—7 days	Fore-	0,032±0,004	9,13±0,92	0,078±0,009	23,18±1,06	0,221±0,018	67,18±1,28
	Hind	0,027±0,003	8,32±0,73	0,055±0,003	16,78±0,94	0,252±0,024	75,08±0,80
12 days	Fore-	0,026±0,006	7,08±0,54	0,073±0,009	19,77±1,98	0,263±0,0971	73,15±1,76
	Hind	0,023±0,003	6,68±0,85	0,065±0,009	18,35±2,55	0,263±0,0167	74,97±2,28
16—23 days	Fore-	0,021±0,001	4,74±0,33	0,086±0,005	19,66±0,72	0,337±0,0296	75,6±0,91
	Hind	0,029±0,001	6,81±0,51	0,067±0,008	17,25±1,89	0,349±0,0366	76,8±2,02
$1^1/_2$—3 months	Fore-	0,023±0,002	5,28±0,49	0,035±0,010	8,48±2,79	0,36±0,0196	86,28±3,11
	Hind	0,026±0,001	6,45±0,34	0,042±0,004	10,72±0,99	0,34±0,021	82,83±1,23

Age	Limb	*T* (in sec)	Pulse rate (P)	V_a (in ohms/sec)	V_b (in ohms/sec)	*Vd*	R_z (in ohms)
4—7 days	Fore-	0,330±0,029		2,63±0,30	0,61±0,12	109,1±20,57	0,126±0,017
	Hind	0,332±0,029	185±9,35	3,38±0,58	0,85±0,22	94,9±15,86	0,133±0,008
12 days	Fore-	0,365±0,018		1,37±0,12	0,26±0,20	34,73±3,84	0,054±0,010
	Hind	0,355±0,017	169,5±8,94	1,28±0,08	0,27±0,23	31,92±5,486	0,049±0,001
16—23 days	Fore-	0,44±0,03	137±8,61	1,85±0,16	0,39±0,06	31,3±5,708	0,068±0,006
	Hind	0,44±0,03		2,23±0,16	0,36±0,07	37,7±5,239	0,087±0,038
$1^1/_2$—3 months	Fore-	0,425±0,012	151,7±8,20	1,53±0,08	0,52±0,04	19,99±2,80	0,045±0,006
	Hind	0,405±0,019		1,68±0,24	0,52±0,07	30,59±4,124	0,065±0,007

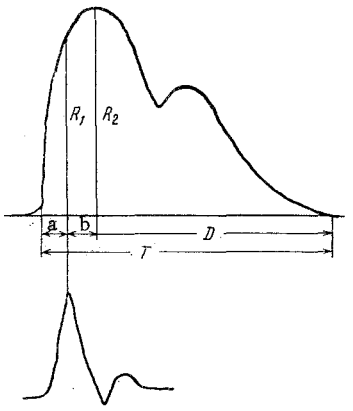

Fig. 1. Diagram showing calculation of rheographic indices. Rheogram shown above, and its first derivative below. Explanation in text.

1) 4-7 days, 2) 12 days, 3) 16-23 days, and 4) $1^1/_2$-3 months after birth. The number of animals in groups 1, 2, and 4 (n) was six, and in group 3 it was eight.

EXPERIMENTAL RESULTS

The results given in Table 1 show that the amplitude of the curve (R_2) was highest in puppies aged 4-7 days and was much lower by the 12th day after birth. By 16-23 days this index showed a certain increase, but it then fell again. The duration of the phase of rapid filling (a) remained almost unchanged with age in absolute value. However, if expressed as a percentage of the total duration of the pulse wave, this index was reduced in the second and third age groups. The duration of the phase of slow filling (b) decreased with age when expressed both in absolute terms and as a percentage of the total duration of the pulse wave. The rate of rise of the curve in the phase of rapid filling (V_a) was highest in the puppies of the first age group and was reduced by the 12th day after birth. Differences between the rates of rise of the curve in the phase of slow filling (V_b) between the group of animals are not significant. The duration of the catacrotic wave (D) and of the whole pulse wave increased with age. The mean rate of fall of the catacrotic wave (V_d) in both the fore- and hind limbs was highest in the first age group. This index showed a decrease by the 12th day after birth. The dicrotic wave was completely absent on the rheograms of the puppies aged 4-7 days. By the 12th day after birth, a very small dicrotic wave appeared on the rheograms of the forelimbs, and by the 16th-23rd days it was also found on the rheograms of the hind limbs. In puppies aged $1^1/_2$-3 months the dicrotic wave was clearly defined on the rheograms of both limbs.

The greater amplitude of the rheograms in the puppies aged 4-7 days discovered in this investigation and, consequently, the greater inflow of blood with the pulse to the skeletal muscles, together with the decrease in amplitude of the rheogram with age, can be interpreted in the light of Mil'man's concept [6]. According to Mil'man, in early postnatal development the volume of the vascular system per unit mass is greater, and it diminishes with age. The reason for this phenomenon is that with an increase in the number of cells during growth of the organism the blood vessels cannot reach every cell, for the simple reason that they can grow in only two directions in space whereas the mass of cells increases in three directions. The greater pulse inflow in puppies aged 4-7 days is combined, as other investigations in the laboratory [1-3] have shown, with low visco-elastic properties of the arterial walls, which in this particular case is evidently reflected in the absence of a dicrotic wave, the maximal rate of rise of the curve in the phase of rapid filling, the longer duration of the period of slow filling, and the shorter duration of the catacrotic wave.

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