DYNAMOCARDIOGRAPHIC EXAMINATION OF HEALTHY CHILDREN AGED 8 TO 15 YEARS

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The new method of investigation of cardiac activity – dynamocardiography (originally named cardiohemodynamography) – was described by E. B. Babskii et al., in 1952 [1]. A number of reports has now appeared on dynamocardiographic studies of patients with various cardiac diseases. However, no special studies of dynamocardiograms in healthy subjects have so far been published.

We needed to know the normal dynamocardiographic characteristics of healthy subjects within the age group of 8 to 15 years for our studies on the dynamocardiographic features exhibited by children suffering from transposition of the great vessels. With this aim in view, we examined 58 healthy schoolchildren within the above age group attending one of the Moscow schools. Conditions of dynamocardiogram recording were the same as those described previously [2, 3].

EXPERIMENTAL METHOD AND RESULTS

The state of health of the children examined was determined from data on their past history, general physical examination, percussion and auscultation of the chest and reports by the school medical officer on each child. Of the 58 children investigated 29 were boys and 29 girls.

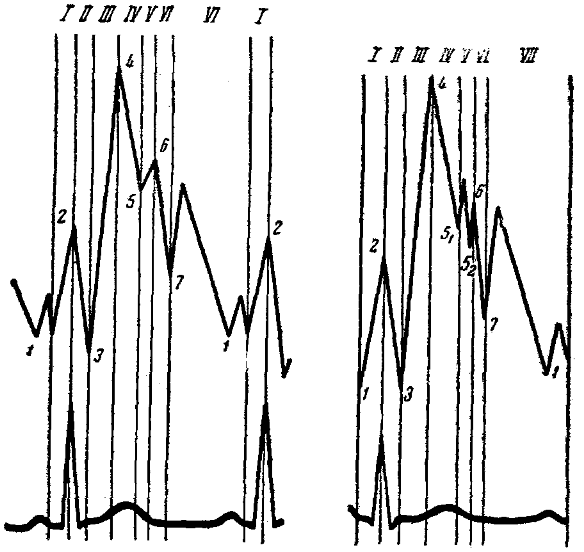
The normal dynamocardiogram of healthy adults, recorded at a film speed of 10 mm/sec, has the appearance of a serrated line (Fig. 1) on which intervals described by the authors [4] and corresponding to the different phases of the cardiac cycle can easily be distinguished.

The first phase of ventricular systole – phase of isometric contraction – is reflected in the dynamocardiogram by the portion of the curve in the interval II. In children this has the form of a straight line sloping downward.

The subsequent phases of ventricular systole – phases of rapid and slow expulsion – are represented on the dynamocardiogram by intervals III and IV. In interval III (rapid expulsion) the curve rises sharply and then, in interval IV (slow expulsion), slopes down to some extent.

In 25 of our observations the curve was notched at the very beginning of interval III with a small notch of low amplitude. The position of this notch was very inconstant. It was most frequently found between the end of interval II and beginning of interval III. In some cases the same subject showed this notch in different positions during different cycles. In such instances it was always referred to the phase of expulsion. Since the presence of this small notch at the beginning of interval III in the dynamocardiogram is observed in healthy children (and in healthy adults) we suppose that this feature is one of the normal dynamocardiographic variants. The origin of this small notch in interval III is not as yet quite clear.

Interval IV is little variable. Interval V corresponds to the protodiastolic period. It is represented by a small portion in the form of a straight line sloping upwards. In 16 observations two protodiastolic periods were noted, following each other in very quick succession. We tend to regard this as asynchronous closure of the semilunar valves of the aorta and pulmonary artery. For convenience of analysis of the dynamocardiogram we distinguish points 5_1 and 5_2 in connection with the presence of two protodiastolic periods, and intervals V corresponding to them (Fig. 1, a and b).



a b

Fig. 1. Schematic drawing of a normal dynamocardiogram. a) Without splitting of the protodiastole, b) with splitting of the protodiastole ($5_1 5_2$). Arabic numerals indicate dynamocardiogram notches. Roman numerals denote the dynamocardiogram intervals. Interval I corresponds to auricular systole, interval II corresponds to the phase of isometric contraction of the ventricles. Interval III corresponds to the period of rapid expulsion of blood from the ventricles and interval IV to the period of slow expulsion, interval V corresponds to the protodiastolic period, interval VI to period of relaxation, interval VII to period of ventricular filling with blood. Intervals II, III, IV corresponding to ventricular systole, intervals I, V, VI, VII correspond to ventricular diastole.

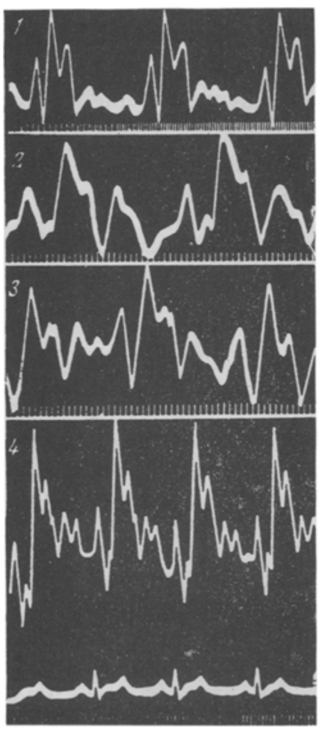


Fig. 2. Variants (1-4) of the normal dynamocardiogram in children aged 8 to 15 years. The electrocardiogram is shown at the bottom of variant 4 as a marker. Time marker 0.05 second.

The next phase in diastole – phase of relaxation – is represented in the dynamocardiogram by interval VI. During this phase the portion of the dynamocardiogram appears as a descending straight line; no other changes have been observed in this part of the dynamocardiogram. Interval VII (phase of filling) has the appearance of a complex broken line, following first an ascending course, then descending, which is evidently connected with rapid and slow filling of the ventricles with blood. Interval I corresponds to auricular systole. This part of the dynamocardiogram is an ascending straight line. In most cases the dynamocardiogram intervals thus have the appearance of straight line segments of a complex broken curve. Four variants of the normal dynamocardiogram for children aged 8 to 15 years can be distinguished on the basis of the facts presented above (Fig. 2).

No changes in any intervals were observed in 25 cases, i.e., 43.1%. Notching in interval III was seen in 16 cases, 26.7%. Splitting of the curve in interval V was noted in 6 cases, i.e., 10.4%. Changes in intervals III and V were seen in 11 cases, i.e., 18.9%.

The amplitudes of the curve during the phase of expulsion of blood from the ventricles and during the phase of contraction were compared for the purposes of amplitude analysis of the dynamocardiogram. These amplitude ratios were expressed as an amplitude coefficient, taking the amplitude during the phase of contraction tion as unity. The amplitude coefficient of the normal dynamocardiogram in children aged 8 to 15 years is 1.8. In adults it equals 2.3 (V. L. Karpman). The 4 variants of the normal dynamocardiogram have approximately the same amplitude coefficient.

Comparison of the dynamocardiogram in healthy children aged 8 to 15 years and in adults with respect to pattern reveals no significant difference. There is only some decrease of amplitude during the phase of blood expulsion in children as compared with adults, which is evidently associated with the smaller volume of blood expelled.

TABLE 1

Mean Duration of Individual Phases of the Cardiac Cycle in Children Aged 8 to 15 Years According to Dynamocardiographic Data

DCG intervals	Phases of the cardiac cycle	Duration in seconds		
		arithmetic mean (M)	mean error of arithmetic mean (± M)	mean square deviation (± σ)
II	Phase of contraction	0,071	0,002	0,013
III	Phase of rapid expulsion	0,113	0,002	0,013
III+IV	Expulsion as a whole	0,210	0,002	0,017
II+III+IV	Ventricular systole	0,281	0,003	0,025
V	Protodiastolic period	0,046	0,001	0,015
VI	Phase of relaxation	0,072	0,002	0,014
VII	Phase of filling	0,090	0,010	0,093
I	Auricular systole	0,089	0,001	0,010
V+VI+VII+I	Ventricular diastole	0,523	0,010	0,100
I—VII	Cardiac cycle	0,800	0,010	0,109

TABLE 2

Limits of Variation of Duration of the Individual Phases of the Cardiac Cycle According to Literature Data and Dynamocardiographic Data

Phases of cardiac cycle	Limits of variation of the duration of individual phases of the cardiac cycle in seconds	
	according to data of various authors	according to present author's data
Ventricular systole	0,19—0,39	0,24—0,34
Phase of contraction	0,14—0,10	0,05—0,10
Phase of rapid expulsion	—	0,08—0,14
Expulsion of blood from ventricles as a whole	0,15—0,36	0,17—0,26
Ventricular diastole	—	0,35—0,71
Protodiastolic period	0,07—0,10	0,02—0,07
Phase of relaxation	0,07—0,10	0,05—0,11
Phase of filling	—	0,011—0,52
Auricular systole	0,09—0,14	0,07—0,10

The mean error of the arithmetic mean and the mean square deviation were determined. The duration of all the phases of the cardiac cycle in children aged 8 to 15 years as shown by the dynamocardiogram data is presented in Table 1.

It should be noted in connection with the data shown in Table 1 that in the case of two protodiastolic periods being present the duration of the expulsion phase was considered to be more correctly estimated up to point 5_2. If the duration were calculated to point 5_1 it would give the time necessary for expulsion of blood only from that ventricle which achieved the task first. If, however, the duration of the expulsion phase is calculated to point 5_2, the time needed for expulsion of blood from both ventricles is determined.

Moreover, when the dynamocardiogram is recorded simultaneously with the electrocardiogram the point 5_2 corresponds in time to the end of electric systole, the T-wave. If the dynamocardiographic data on the expulsion phase calculated to point 5_1 and point 5_2 are compared with literature data a more satisfactory agreement is found to exist in the latter case.

Consequently, everywhere two protodiastolic periods were present on the dynamocardiogram the duration of the expulsion phase was calculated to point 5_2.

TABLE 3

Mean Duration of the Individual Phases of Cardiac Contraction Depending on the Total Duration of the Cardiac Cycle in Children Aged 8 to 15 Years

Phases of the cardiac cycle	Duration of individual phases of cardiac contraction when the total duration of the cycle is				
	0,60—0,69	0,70—0,79	0,80—0,89	0,90—0,99	1,00—1,09
Ventricular systole	0,26	0,27	0,28	0,31	0,31
Phase of contraction	0,06	0,07	0,07	0,08	0,08
Phase of rapid expulsion	0,11	0,11	0,11	0,11	0,12
Expulsion of blood from ventricles as a whole	0,20	0,20	0,21	0,23	0,23
Ventricular diastole	0,36	0,47	0,53	0,62	0,70
Protodiastolic period	0,03	0,04	0,05	0,05	0,05
Phase of relaxation	0,07	0,07	0,07	0,07	0,08
Phase of filling	0,18	0,27	0,32	0,41	0,47
Auricular systole	0,08	0,09	0,09	0,09	0,10
Rhythm of cardiac contractions	95	82	76	65	61

TABLE 4

Duration of Intervals of Individual Phases of the Cardiac Cycle in Children of Different Age Groups

Phases of cardiac cycle	Age groups		
	from 8 to 11 years	from 12 to 15 years	from 20 to 60 years (V. L. Karpman)
Ventricular systole	0,275	0,281	0,301
Phase of contraction	0,070	0,073	0,074
Phase of rapid expulsion	0,109	0,112	0,112
Expulsion of blood from the ventricles as a whole	0,205	0,208	0,227
Ventricular diastole	0,495	0,545	0,579
Protodiastolic period	0,048	0,045	0,032
Phase of relaxation	0,071	0,075	0,093
Phase of filling	0,288	0,335	0,376
Auricular systole	0,089	0,090	0,078
Duration of cycle	0,771	0,826	0,880

We have found a limited number of reports in Soviet and foreign literature on analysis of the individual phases of cardiac contraction in healthy subjects. These were usually arrived at from various and most often complex methods of investigation. We could find no data on the duration of the individual phases of the cardiac cycle in healthy children within the age-group of 8 to 15 years. We could therefore only compare the values obtained by us for the duration of the cardiac cycle phases in adolescents with data obtained on adults. Since different authors give highly divergent mean values of duration of the individual phases of the cardiac cycle we took for comparison the limits of fluctuation of these values and presented them in the form of Table 2.

The certain discrepancy between the duration of the individual phases of the cardiac cycle as determined by dynamocardiography and the data of other authors can be explained by the differences in the rhythm of cardiac activity, since it is known that the duration of the individual phases of cardiac contraction depends on the total duration of the cardiac cycle. This dependence is presented in Table 3, based on dynamocardiographic data.

The results of our investigations, summarized in Table 4, suggest some relation of the duration of individual phases of the cardiac cycle to the age of the children.

SUMMARY

Dynamocardiography (cardiohemodynamography) gives an opportunity to study the hemodynamics and to judge the contractility of myocardium. Temporal analysis of all phases of cardiac activity may be carried out by the method of dynamocardiography. Fifty-eight healthy boys and girls aged 8 to 15 years were examined. The specific features of their dynamocardiograms were studied with relation to age.

The normal dynamocardiogram of healthy children has the form of a complex broken line with a characteristic pattern. There are 4 variants of the normal dynamocardiogram in children.

LITERATURE CITED

[1] E. B. Babskii, V. S. Gurfinkel', Z. A. Romel' and Ia. S. Iakobson, Doklady Akad. Nauk SSSR 83, No. 6, 957-960 (1952).

[2] E. B. Babskii, A. L. Miasnikov, V. S. Gurfinkel', K. N. Zamyslova and E. L. Romel', Terap. Arkh. No. 1, 68-76 (1952).

[3] E. B. Babskii, T. S. Vinogradova and V. L. Karpman, Khirurgiia No. 1, 60-67 (1954).

[4] E. B. Babskii, T. S. Vinogradova, V. S. Gurfinkel' and E. N. Meshalkin, Doklady Akad. Nauk SSSR 88, 2, 362-368 (1953).