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EVALUATION OF CARDIAC HYPERTROPHY IN RATS BY VECTORCARDIOGRAPHY PART I. RELATIONSHIP BETWEEN CARDIAC MASS AND MAXIMAL SPATIAL QRS VECTOR

(rat/vectorcardiography/cardiac mass)

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On vectorcardiogram in Wistar Kyoto rats, the relationship between maximum spatial QRS vector determined accurately by VCG analyser(VAC-3) and the index of ventricular mass was analysed. In the Frank and McFee Parungao lead systems there were no significant correlations between the magnitude of maximum spatial QRS vector and the measurements of heart and ventricles. These results suggest the necessity to modify the Frank and McFee Parungao lead systems, or to produce a new lead system for rats.

The vectorcardiographic approach is very useful in estimating cardiac hypertrophy in man. Previous investigations by vectorcardiography(VCG) in rats(1-3) have revealed a relationship between the indices of ventricular hypertrophy and the maximum spatial QRS vector. However, the maximum spatial QRS vector in the previous reports might be inaccurate, because the magnitude of maximum spatial QRS vector was calculated from the maximum vector in frontal, sagital and horizontal planes. The purpose of this report is to analyse the relationship between the index of ventricular mass and the real maximum spatial QRS vector which was calculated accurately by VCG analyser.

MATERIALS AND METHODS

Ordinary normotensive Wistar rats of the Kyoto strain(WKY) at the following ages(and numbers) were used in the present study, 6 rats aged 6 months and 8 rats aged 12 months. All rats

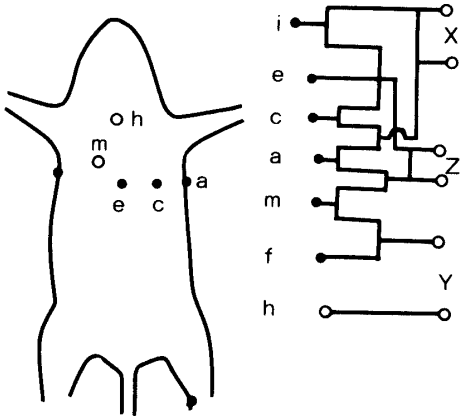

Fig.1. Position of leads of Frank method.

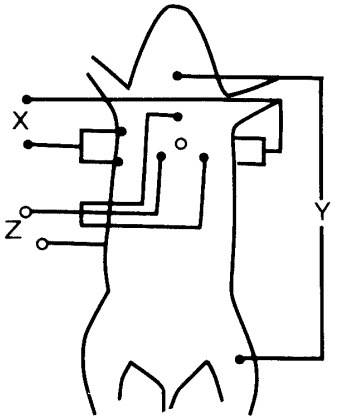

Fig.2. Position of leads of McFee Parungao method.

were male. Indirect tail blood pressure was measured by the tail cuff method in a conscious state. The animals were anesthetized with pentobarbital sodium(30 mg/kg) and the hair was neatly cut. The rats were set to the vectorcardiographic equipment in the prone position. Small needle electrodes, inserted into the skin at intervals of about 2 mm, were used for each of the leads. VCGs were taken by the Frank lead and the McFee Parungao lead systems. In the Frank lead system, positions and resistance were determined following the original method(4)(Fig.1). In the McFee Parungao lead system, they were decided by the modified Sekiya method(7)(Fig.2) of the McFee lead(5,6). VCG analysers(VAC-3: Fukuda denshi Co.) were used for recording and analysis of the VCG. After recording the VCG, the rats of all experimental groups were killed and the weight of the whole heart and each ventricle were measured.

RESULTS

Age, body weights(BW) and indirect tail blood pressure are shown in Table I. The weight of the whole heart and each ventricle are listed in Table II. Between 6 and 12 month-old rats, there was no significant difference in blood pressure nor in the ratio of whole heart weight to BW(HW/BW: %), of the left ventricular weight to BW(LV/BW: %) and of the right ventricular weight to BW(RV/BW: %), respectively. Fig.3 shows the relationship between the maximum spatial QRS vector in the Frank lead and

Table I. BODY WEIGHT AND BLOOD PRESSURE BY AGE

Age (mon.)	6	12	Test† (p)
No. of aninals*	6	8	
Body weight (g)	324±20	431±12	S(<0.05)
Blood pressure (mmHg)	130± 5	135± 8	S(<0.01)

* Wistar-Kyoto rats
† S: statistically significant

Table II. WEIGHTS OF WHOLE HEART AND EACH VENTRICLES BY AGE

Age (mon.)	6	12	Test† (p)
No. of animals	6	8	
Whole heart weight (g)	0.88±0.12	1.15±0.13	S(<0.01)
Whole heart weight/BW, (%)	0.27±0.02	0.27±0.04	NS
LV weight (g)	0.68±0.06	0.88±0.10	S(<0.01)
LV weight/BW, (%)	0.21±0.01	0.20±0.10	NS
RV weight/BW, (%)	0.06±0.01	0.06±0.01	NS

BW: Body weight, LV: Left ventricle, RV: Right ventricle
† S: statistically significant, NS: not significant

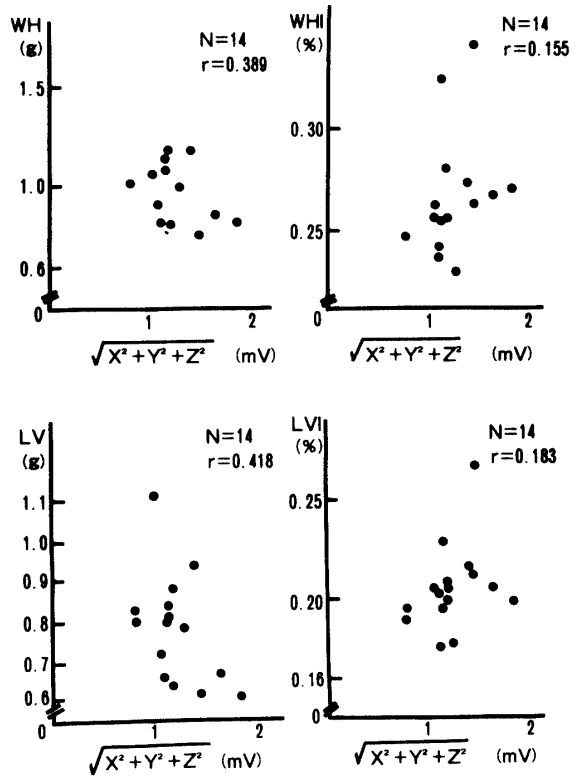

Fig.3. Correlation between the maximum spatial QRS vector by Frank system and measurements of heart and ventricles. WH: whole heart weight, WHI: ratio of WH to body weight, LV: left ventricular weight, LVI: ratio of LV to body weight.

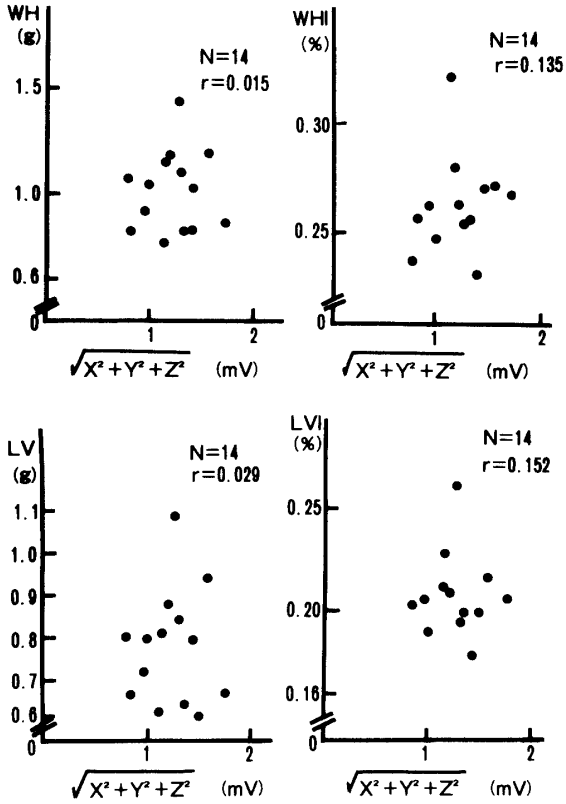

Fig.4. Correlation between the maximum spatial QRS vector by McFee Parungao system and measurements of heart and ventricles. WH: whole heart weight, WHI: ratio of WH to body weight, LV: left ventricular weight, LVI: ratio of LV to body weight.

each index of weight of the whole heart and the left ventricle. Fig.4 shows the relationship between the maximum spatial QRS vector in the McFee lead and the above-mentioned index. There were no significant correlations between them in either lead.

DISCUSSION

It has been suggested that left ventricular hypertrophy occurs even in the prehypertensive stage(8) in spontaneously hypertensive rats(SHR), which is generally the best model developed to date as an experimental counterpart for essential hypertension in man(9). Clinically, our extensive surveys of school children(Shimane Heart Study(10,11)) have revealed echocardiographically determined cardiac hypertrophy in borderline hypertensive children. It is very important to find out the subject with cardiac hypertrophy in the prehypertensive or very early hypertensive stage in order to prevent hypertensive

disease. Vectorcardiogram might be most useful to estimate cardiac hypertrophy instantaneously and economically. Therefore, many investigators(1,12) have reported VCG findings in both normotensive and hypertensive rats. In the previous reports, the magnitude of maximum spatial QRS vector did not give the true value because it was calculated from the magnitudes of maximum QRS vector in frontal, sagital and horizontal planes. So, in the present study, the magnitude of maximum spatial QRS vector was obtained as follows. Using the VCG recorded on magnetic tape, the magnitude of spatial QRS vector was calculated automatically at intervals of 1.25 millisecond by VCG analyser, and the largest magnitude was adopted as the magnitude of maximum spatial QRS vector.

In our study on both the Frank and McFee lead systems, there was no significant correlation between the magnitude of the maximum spatial QRS vector and the measurements of heart and ventricles. There seem to be three reasons for this. The first is that these leads were derived from the torso model of a man or a dog. Therefore, the resistance balance of lead in the rat may be different from that in the man. The second is an anatomical difference between rats and man, such as the position of the heart and the configuration of the thorax. The third is the unstable positioning of the electrodes because of the movable skin of the rat. Therefore, it is necesary to modify the lead system or produce a new system for the rat. Previously, we suggested that the precordial voltage(SV_1+RV_5) corrected by the square of the radius of the circle with equal circumference to the thorax(R^2) was well correlated with the left ventricular muscle volume(LVMV), although correlation of the precordial voltage(SV_1+RV_5) with LVMV was not close(13). This method might be also useful for the rat.

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