ELECTROCARDIOGRAM AND VECTORCARDIOGRAM IN ISOLATED COMPLETE RIGHT BUNDLE BRANCH BLOCK PART I CLINICAL STUDIES

TSUNETO TOKUNAGA

Forty-seven subjects with isolated complete right bundle branch block (CRBBB) were analyzed electrocardiographically and vectorcardiographically utilizing the Frank lead system. Two basic electrocardiographic patterns of group A and group B, and 5 vectorcardiographic patterns of type A, type Ab and type ab belonging to group A, and type aB and type B to group B, were identified. The duration of the S wave in lead II in group A was equal to or larger than 0.08 sec, while in group B it was equal to or below 0.08 sec. In group A, the mid-temporal portion of QRS-loop was displaced more posteriorly, superiorly and to the right than that in group B. As regards the mean electrical axis, group A is generally closer to CRBBB with left anterior hemiblock (LAH) than group B, while group B is to CRBBB with left posterior hemiblock (LPH) than group A.

Fifteen (79%) of 19 subjects with hypertension and/or atherosclerosis had the type A, type Ab and type ab QRS-loop patterns, 2 subjects with variant type of angina pectoris out of 4 exceptions showing the type B QRS-loop patterns. On the other hand, 6 of 7 subjects with chronic lung disease and 10 of 21 subjects with no evidence of cardiopulmonary disease had the type aB and type B QRS-loop patterns.

Fortunately, a 62-year-old man with essential hypertension and bronchial asthma was found to have intermittent group A and group B of isolated CRBBB confirmed by 12-lead electrocardiogram (ECG) and vectorcardiogram (VCG).

On the basis of these findings, it is suggested that there would be some difference in propagation of the cardiac impulse, induced by disease, between group A and group B.

IN RECENT years, isolated CRBBB with marked left or right axis deviation (LAD or RAD) has been extensively studied in the ECG and even in the VCG. Less attention has been given to the multiple patterns of isolated CRBBB.

Key Words:

Isolated Complete Right Bundle Branch Block
Frank Lead System
Hypertension and/or Atherosclerosis

It may be, in part, due to the difference in propagation of the cardiac impulse among multiple patterns of isolated CRBBB that various vectorcardiographic and electrocardiographic studies in RBBB with coexisting left or right ventricular hypertrophy (LVH or RVH) have yielded somewhat conflicting and, in some instances, controversial results!¹⁻⁵

Detailed analysis of the QRS-loop could sometimes provide the only source of information

(Received for publication, June 5, 1973)

The First Department of Internal Medicine, Okayama University Medical School, Okayama

* The present investigation was reported in a preliminary form, at the 35th Annual Meeting of the Japanese Circulation Society, April, 1971, in Tokyo, Japan.

about propagation of the cardiac impulse in the human heart.

The purpose of the present investigation is to divide the Frank VCGs and ECGs in isolated CRBBB and to discuss about differences in etiology.

SUBJECTS AND METHODS

A 12-lead ECG was taken in each case with standard direct writer electrocardiograph. VCGs in the frontal (F), left sagittal (LS) and horizontal (H) planes were recorded in the supine position using the Frank lead system⁶. The fifth intercostal space was used for placement of the chest electrodes. The VCGs were recorded with the use of the Fukuda Electro Co. Model VA-3C-5. The oscilloscopic beam was interrupted electronically every 1.25 msec. The loops were photographed from the oscilloscopic screen with a Canon FX camera.

Forty-seven subjects whose ECGs and VCGs fulfilled the conventional criteria for diagnosis of isolated CRBBB were selected for study. The most evident electrocardiographic and vectorcardiographic signs for the diagnosis of isolated CRBBB are: (1) QRS duration of 0.12 sec. or more in the standard leads; (2) large bifid or slurred R waves in leads from right side of the precordium; (3) a delayed onset of intrinsicoid deflection in the right precordial leads (0.09 sec. or more), with ventricular activation time of less than 0.06 sec. in V_6 ; and (4) exclusion of LAH and LPH in the presence of CRBBB.

Left anterior hemiblock was diagnosed according to the criteria of *Rosenbaum et al.*⁷ and *Pryor and Blount*⁸: (a) abnormal LAD (between

-30° and -90°); (b) small r waves in leads II, III and aV_F ; (c) counterclockwise (CCW) rotation of the frontal plane QRS-loop; and (d) exclusion of other causes of abnormal LAD. The diagnosis of LPH required⁷⁻⁹: (a) $\dot{A}QRS$ between $+90^\circ$ and $+130^\circ$; (b) small q waves in leads II, III and aV_F ; (c) clockwise (CW) rotation of the frontal plane QRS-loop; and (d) exclusion of other causes of RAD. Either LAH or LPH can be diagnosed in the presence of CRBBB.

Subjects with isolated CRBBB associated with myocardial infarction or manifest ventricular hypertrophy on the basis of physical, X-ray and laboratory data were not included in this series. The age of this series ranged from 12 to 75 years with a mean of 55.3 years; of this number 31 were male (Table I).

The following qualitative and quantitative parameters were analyzed:

- (1) QRS-loop configuration.
- (2) Direction of inscription of the QRS-loop.

(The QRS-loops in the 47 subjects comprising this study series were classified into 5 types by these parameters in the three planes.)

- (3) Duration of the S wave in lead II.

Fig.1. Duration and amplitude of the S wave in lead II in group A and group B of isolated CRBBB.

Fig.2. Comparison of characteristic vector loops of group A (type A, type Ab and type ab) and group B (type aB and type B) in the three planes. Note differences in shape and position of the mid-temporal vectors. Arrows indicate the direction of the loops.

TABLE I AGE AND SEX DISTRIBUTION OF SUBJECTS STUDIED

Age (years)		10-19	20-29	30-39	40-49	50-59	60-69	70-79	Total
Sex	Male	0	1	1	3	10	13	3	31
	Female	2	1	3	1	2	6	1	16
Total		2	2	4	4	12	19	4	47

(The ECG in these 47 subjects presented S waves which permitted classification into two groups.)

(4) Amplitude of the QRS complexes in selected leads.

(5) Direction of the half-area QRS vector in the frontal plane.

(6) Amplitude of the R and S waves in leads I and II.

(7) Magnitude, azimuth and elevation of the spatial maximum QRS vector in the unblocked QRS-loop.

(The reference frames used in this study are the same as in the 6th Meeting of the Japanese Society for the Study of VCG¹⁰)

(8) Direction of the initial vector and the initial and terminal maximal mean instantaneous QRS vector in the horizontal plane.

(As described by Bayder *et al.*³, the initial maximal mean instantaneous QRS vector is the maximal vector for the first half of the loop and is directed to the left. The terminal maximal mean instantaneous QRS vector is the maximal vector of the terminal appendage of the loop and is usually directed to the right and anterior.)

(9) Magnitude of the projections of the QRS-loop along the horizontal (X), frontal (Y) and sagittal (Z) axes.

(10) PQ duration.

(11) QRS duration.

Conventional reference frames for the horizontal and frontal planes were employed for the study of angular measurements. The reference frame for the left sagittal plane was aligned so that 0° was posterior, +90° inferior and +180° anterior.

RESULTS

Vectorcardiographic and electrocardiographic classification

Analysis of the 47 VCGs revealed that the majority fell into two basic patterns, with the rest in an intermediate category that showed mixed features. The characteristic distinguishing features of the two main types, type A and type B, were found in the three planes. The mid-temporal vector in type A is markedly projected posteriorly, superiorly and to the right, whereas that in type B is lacking in such features.

Since the duration of the S wave in lead II in type A was equal to or larger than 0.08 sec, while in type B was equal to or below 0.08 sec, the present series including an intermediate type, type AB, were classified into two groups, group A and group B, according to the duration (Fig. 1). There was a mean of 0.093 sec. with a range of 0.08 to 0.12 sec. for the duration of

Fig.3. Comparison of characteristics vector loops of type A and type B in type II and type III as well as in type I. Arrows indicate the direction of the loops.

Fig. 4. Vectorcardiographic and electrocardiographic findings in I-3-A (upper) and II-2-B (lower) of isolated CRBBB. In the ECG lead II, the S duration of more or less than 0.08 sec. is indicative of the difference of one group from the other. The former 62-year-old man had essential hypertension, and the latter 32-year-old man had paroxysmal tachycardia. Arrows indicate the direction of the loops.

QRS in group A, a mean of 0.051 sec. with a range of 0.03 to 0.08 sec. in group B. The former included type A, type Ab and type ab, while the latter type aB and type B.

The characteristic distinguishing features are described as follows (Figs. 2 and 3).

I) Group A (The ECGs have II_S duration of 0.08 sec. or more.)

1) Type A QRS-loop (15 cases). The QRS-loop in the three planes is markedly projected posteriorly, superiorly and to the right without distinction of the direction of inscription of the loop.

2) Type Ab QRS-loop (10 cases). The QRS-loop in the three planes has a smaller rightward posterior and superior projection than that of type A.

3) Type ab QRS-loop (3 cases). The QRS-loop in the three planes is lacking such features as type A QRS-loop, but the mid-temporal vector has a projection accentuated rightward.

II) Group B (The ECGs have II_S duration equal to or below 0.08 sec.)

1) Type B QRS-loop (15 cases). The QRS-loop in the three planes is lacking in a posterior and superior projection and smaller in a rightward projection than the others, without distinction of the direction of inscription of the QRS-loop.

2) Type aB QRS-loop (4 cases). The QRS-

loop in the three planes is not projected posteriorly, superiorly and to the right, but has a smaller rightward projection.

The QRS-loop in isolated CRBBB also was symbolized with the following figures.

I: The horizontal plane loop is inscribed CCW for its major portion.

II: The horizontal plane loop shows a figure-of-eight in the first half; the central loop is anterior.

III: The horizontal plane loop is inscribed CW in the first half.

1: The frontal plane loop is inscribed CW in the first half.

2: The frontal plane loop shows a figure-of-eight in the first half.

3: The frontal plane loop is inscribed CCW in the first half.

Therefore, all the QRS-loops in isolated CRBBB, which showed bizarre configurations, can be displayed in such a way as I-3-A, II-2-B and III-1-A (Figs. 4 and 5).

Clinical correlation

Twenty-eight ECG and VCG patterns fell into the group A (type A, type Ab and type ab) category. Clinical data (Fig. 6) revealed that 15 subjects had evidence of clinical hypertension and/or atherosclerosis, and the only one subject was complicated by chronic lung disease, bronchial asthma, in this group. Thirteen subjects had no clinical evidence of either hypertension and/

Fig.5. Characteristic VCG and ECG in III-1-A of isolated CRBBB. Note the CW rotation in the first half of the horizontal QRS-loop. This 56-year-old man had essential hypertension, diabetes mellitus, fatty liver, and no physical and roentgenologic evidence of chronic lung disease.

or atherosclerosis or chronic lung disease.

Nineteen ECG and VCG patterns were included in group B (type aB and type B). Six subjects had clinical and roentgenologic evidence of chronic lung disease. Hypertension and/or atherosclerosis were possibly present in 4, but 2 of them were definitely recognized to be variant type of angina pectoris with the injury to the

inferior wall (Fig. 7).

Figure 8 shows the relationship of age and etiologic diagnosis to the patterns of QRS-loop. It is of interest that Figs. 6 and 8 show the majority of subjects with hypertension and/or atherosclerosis being more predominant in type A rather than in type B even in the same age group.

Type	H	I			II			III			Total
		1	2	3	1	2	3	1	2	3	
A	F	Δ	○○○ OX	○○○ X		○	○○	○	○		15
	Ab	ΔX	○○X	○○X			XX				
	ab	○○							X		
	aB	○○X						X			
B	F	●●● X	XXX X	○		XX		X			15
	Ab										
	ab										
	aB										

○ = Hypertension and/or atherosclerosis
 ⊖ = Variant type of angina pectoris
 ● = Chronic lung disease
 Δ = Under twenty years of age
 X = Other than above-mentioned

⊙ = ○ + ●
 ⊖ = ⊖ + ●
 F = Frontal
 S = Sagittal
 H = Horizontal

Fig.6. Relationship of etiologic diagnosis to the author's classification of isolated CRBBB. For explanation of the other symbols see the text.

Fig.7. Vectorcardiographic and electrocardiographic findings in I-1-B of isolated CRBBB. This 56-year-old woman had variant type of angina pectoris. The ECG was recorded within a few minutes after the onset of pain. The marked elevation of the ST segment in leads II, III and aVF with reciprocal depression of the ST segment in standard leads I and aVL suggests that the right coronary artery is involved. Arrows indicate the direction of the loops.

Figure 9 shows the relationship of hypertension to amplitude of the R and S waves in the selected leads, and Fig. 10 reveals that of chronic

Fig.8. Relationship of age and etiologic diagnosis to the pattern of QRS-loops. The cases are distributed on the abscissa according to the author's classification of isolated CRBBB. Abbreviations and symbols are the same as in Fig.6.

Fig.9. Amplitude of the R and/or S waves in the selected leads in 47 subjects with or without hypertension. Mean values are represented by the horizontal bars.

lung disease to amplitude of the R' wave and R'/S ratio in lead V_1 . There is no significant difference in amplitude of the QRS waves be-

Fig.10. Amplitude of the R' wave and the R':S ratio in lead V_1 in 47 subjects with or without chronic lung disease.

tween the subjects with hypertension and/or atherosclerosis and the others, and between the subjects with chronic lung disease and the others. Significance of each selected parameters

As seen in Figs. 11, 12 and 13, the mean maximum QRS-loop angle (vector) and the mean axis of QRS complexes are less useful than the R/S ratio in lead II for distinguishing group A from group B.

Table II shows the spatial maximum vector of the unblocked QRS-loop (for the methods of measuring see Fig. 14). There is no significant difference in the magnitude and azimuth between group A and group B, while the elevation of group A is larger ($P < 0.005$) than that of group B.

Table III shows the direction of the initial

TABLE II MAGNITUDE, AZIMUTH AND ELEVATION OF THE SPATIAL MAXIMUM QRS VECTOR IN THE UNBLOCKED QRS-LOOP

Group		Magnitude (mV)	Azimuth ($^{\circ}$)	Elevation ($^{\circ}$)	X (mV)	Y (mV)	Z (mV)
A	Mean	1.27	20.4	58.3**	1.10	-0.56**	0.44
	S. D.	0.55	16.0	29.8	0.37	0.29	0.37
B	Mean	1.50	9.3	50.3**	1.00	-0.97**	0.18
	S. D.	0.51	24.7	12.1	0.35	0.48	0.43
Total	Mean	1.36	15.9	55.1	1.06	-0.73	0.33
	S. D.	0.55	20.0		0.37		0.41

** : Difference is statistically significant ($P < 0.005$).

TABLE III DIRECTION OF THE INITIAL VECTOR AND THE INITIAL AND TERMINAL MAXIMAL MEAN INSTANTANEOUS QRS VECTOR IN THE HORIZONTAL PLANE

	Initial vector		Initial maximal mean instantaneous QRS vector		Terminal maximal mean instantaneous QRS vector	
	Mean	Range	Mean	Range	Mean	Range
Group A	108.3	43-170	21.2	-9-43	132.9	107-169
Group B	100.7	28-145	7.4	-90-45	128.5	107-180
Total	105.2	28-170	15.6	-90-45	131.1	107-180

All measurements are in angular degrees.

Fig.11. Range of the mean maximum QRS-loop angle (vector) in the frontal plane of group A and group B of isolated CRBBB.

vector and the initial and terminal maximal mean instantaneous QRS vector in the horizontal plane. From listed data, it appeared that these parameters did not differ from one group to the other. In group B, the average angle of the initial maximal mean instantaneous QRS vector is less than in group A, because the group B probably included a few subjects with pulmonary emphysema.

Table IV shows the magnitude of the projections of QRS-loop along the X, Y and Z axes. In group A, the magnitudes of Y ($P<0.001$) and $-Y$ ($P<0.005$) and the ratios of $-Y/Y$ ($P<0.001$) are significantly more than in group B, because both groups are classified according to whether or not there is a mid-temporal portion markedly pro-

Fig.12. Amplitude of the R and S waves in lead I.

jected posteriorly, superiorly and to the right.

Table V shows the amplitude of the QRS complexes in selected leads. From the Table V, it appeared that the amplitudes of R_{aVL} ($P<0.05$), R_{aVF} ($P<0.005$), S_{aVF} ($P<0.001$) and S/R_{aVF} ($P<0.001$) significantly differed from one group to the other. It may be due to the difference in ΔQRS that S/R_{aVF} is less in group B than in

TABLE IV MAGNITUDE OF THE PROJECTIONS OF QRS-LOOP ALONG THE X, Y AND Z AXES

	X axis			Z axis				Y axis		
	X	-X	-X/X	Init. Z	Term. Z	-Z	-Z/Z	Y	-Y	-Y/Y
Group A										
No.	28	28	28	27	28	28	27	*** 28	** 28	*** 28
Mean	1.03	0.57	0.63	0.54	0.46	0.38		0.58	0.24	0.53
(S.D.)	(0.54)	(0.17)	(0.28)	(0.22)	(0.20)	(0.23)		(0.27)	(0.12)	(0.42)
	1.73	0.92	1.44	1.00	0.92	0.98		1.13	0.50	1.92
Range	0.35	0.30	0.20	0.10	0.13	0.00		0.12	0.00	0.00
Group B										
No.	19	19	19	18	19	19	18	*** 19	** 19	*** 19
Mean	1.00	0.45	0.47	0.56	0.50	0.25		0.98	0.13	0.14
(S.D.)	(0.36)	(0.19)	(0.19)	(0.24)	(0.22)	(0.23)		(0.46)	(0.08)	(0.08)
	1.80	0.87	1.00	0.95	0.98	0.87		2.20	0.30	0.24
Range	0.41	0.19	0.21	0.23	0.13	0.00		0.28	0.00	0.00
Total										
No.	47	47	47	45	47	47	45	47	47	47
Mean	1.02	0.52	0.56	0.55	0.47	0.33	0.65	0.74	0.20	0.37
(S.D.)	(0.36)	(0.19)	(0.26)	(0.23)	(0.21)	(0.24)	(Wide)			

All measurements are in millivolts.

Abbreviation

X: Maximum left projection
 -X: Maximum right projection
 Init. Z: Maximum initial anterior projection
 Term. Z: Maximum terminal anterior projection
 -Z: Maximum posterior projection
 Y: Maximum inferior projection
 -Y: Maximum superior projection
 Wide: Wide scatter

*** Difference is statistically significant ($P < 0.001$);

** Difference is statistically significant ($P < 0.005$).

group A.

PQ duration. There was a mean of 0.178 sec. with a range of 0.13 to 0.27 sec. for the PQ duration in group A, a mean of 0.177 sec. with a range of 0.13 to 0.22 sec. in group B, and a mean of 0.177 sec. in total.

QRS duration. There was a mean of 0.150 sec. with a range of 0.13 to 0.17 sec. for the QRS duration in group A, a mean of 0.138 sec. with a range of 0.12 to 0.17 sec. in group B, and a mean of 0.145 sec. in total.

CASE REPORT

The ECGs and VCGs were recorded from a 62-year-old man with essential hypertension and bronchial asthma.

Electrocardiographic findings

ECG taken on November 1, 1971 shows group

B of isolated CRBBB (Fig. 15). Figure 16 is a subsequent record recorded on November 3, 1971, showing group A of isolated CRBBB. Note that the S wave in lead II has become broadened. Figure 17 illustrates all the complexes in the twelve leads taken on November 7, 1971. Both groups of isolated CRBBB appeared intermittently. Figure 18 reveals continuous tracings of lead II taken on June 13, 1972. Note that respiratory maneuver cannot cause the change from group A into group B.

Vectorcardiographic findings

Figure 19 illustrates vectorcardiographic loops recorded on November 7, 1971. Upper three planes in group A reveal a mid-temporal portion directed more posteriorly, superiorly and to the right than that of group B in the lower.

Comment

Fig.13. Amplitude of the R and S waves in lead II.

Fig.14. Method of measuring the spatial maximum QRS vector in the unblocked QRS-loop.

This "experiment of nature" affords an opportunity for direct study of the effects of group A and group B of isolated CRBBB in the human being. This is the syndrome of intermittent group A and group B of isolated CRBBB. This case provides a direct evidence for the existence of group A of isolated CRBBB, and group B of isolated CRBBB; and this proves that some difference in impulse propagation between both

Fig.15. ECG on November 1, 1971, of a 62-year-old man with essential hypertension and bronchial asthma. This ECG illustrates group B of isolated CRBBB.

Fig.16. ECG on November 3, 1971, of the same case as shown in Fig.15, revealing group A of isolated CRBBB. Note that the S wave in lead II has become broadened.

Fig.17. All the complexes on November 7, 1971, of the same case as shown in Figs. 15 and 16, showing group A and group B of isolated CRBBB appearing in intermittently.

Fig.18. Continuous tracings on June 13, 1971, of the same case as shown in Figs. 15, 16 and 17. Note that respiratory maneuver cannot cause the change from group A into group B.

groups may arise according to the differences in etiology.

DISCUSSION

In recent years, there is a general agreement that the combination of RBBB and marked LAD or RAD is the most common form of so-called bilateral bundle branch block,¹¹ and it is recognized that this combination is a fairly frequent forerunner of complete heart block.¹²⁻¹⁴ This opinion is substantiated by careful pathologic,¹⁵⁻¹⁹ clinical,²⁰⁻²⁴ electrocardiographic²⁵⁻³⁰ and electrophysiologic^{14,31-33} correlative studies and by experimental works on canine³⁴ and primate³⁵ hearts.

The vectorcardiographic details^{2,20,36-41} of these combinations have been thoroughly studied and classified. Moreover, the vectorcardiographic criteria for diagnosis of each hemiblock have been proposed.⁴¹⁻⁴⁵ Many authors^{12,41-48} observed the vectorcardiographic findings in the frontal and sagittal planes rather than in the

Fig.19. Same case illustrated in Figs.15 to 18. Simultaneous vectorcardiograms demonstrating group A of isolated CRBBB in the top three panels and group B of isolated CRBBB in the bottom three panels.

horizontal plane, which appeared to be most useful in the diagnosis of LAH and LPH, respectively, with or without CRBBB. Nevertheless, studies of the vectorcardiographic patterns in the three planes of isolated CRBBB remain hitherto a very few. Ueda *et al.*⁴⁹ have classified the RBBB in VCG with Frank system solely by the QRS-loop rotation in the three planes. Toyama *et al.*⁵⁰ have discussed the difference in VCG between six types divided in the horizontal plane alone. Some authors^{51,52} have performed vectorcardiographic studies in RBBB with the cube system. It seems to be that there have been no electrocardiographic and vectorcardiographic classifications of isolated CRBBB according to the duration of the S wave in lead II and the pattern of the QRS-loop in the three planes.

TABLE V AMPLITUDE OF THE QRS COMPLEXES IN SELECTED LEADS

	R_I+S_{III}	R_{V_5}	R_{V_6}	R_{aV_L}	R_{aV_F}	S_{aV_F}	S/R_{aV_F}	R'_{V_1}
Group A				*	**	***	***	
Mean	1.01	1.89	1.27	0.44	0.38	0.28	1.34	1.13
(S.D.)	(0.54)	(0.77)	(0.57)	(0.31)	(0.26)	(0.19)	(1.43)	(0.32)
Group B				*	**	***	***	
Mean	0.76	1.79	1.48	0.25	0.74	0.09	0.11	1.18
(S.D.)	(0.37)	(0.66)	(0.59)	(0.22)	(0.43)	(0.09)	(0.10)	(0.41)
Total								
Mean	0.91	1.85	1.35	0.36	0.53	0.20	0.84	1.15
(S.D.)	(0.49)	(0.73)	(0.59)					(0.36)

All measurements are in millivolts.

***: Difference is statistically significant ($P < 0.001$);

**: Difference is statistically significant ($P < 0.005$);

*: Difference is statistically significant ($P < 0.05$).

In the present study, the five types are divided by pattern of the QRS-loop in the three planes and the two groups are classified by the duration of the S wave in lead II. A significant difference between two groups is in the elevations of the spatial maximum vector of the unblocked QRS-loop, the magnitudes of Y and $-Y$, the ratios of $-Y/Y$, and the amplitudes of R_{aV_L} , R_{aV_F} , S_{aV_F} and S/R_{aV_F} . In other words, group A has the pattern of CRBBB in the horizontal heart similar to that described by Goldberger⁵³ and has the characteristics close to those of the CRBBB with LAH, while group B has the similar pattern of CRBBB in the vertical heart and has the characteristics close to the CRBBB with LPH.

According to Uhly and Rivkin,⁵⁴ when the anterior or lateral branches were cut, the terminal forces increased superiorly and corresponding increased S waves occurred in the S-I axis. Conversely, when the posterior branches were cut, the terminal forces were directed inferiorly and a slurring (r') appeared on the downstroke of the R wave in the S-I axis. Their studies appear to support the significance of the S wave in lead II, which similar to that of the S-I axis, as a parameter distinguishing group A from group B. In group A, the broadened S wave in lead II and the posterior-superior-rightward projected mid-temporal vector are present, and these probably may be due to delaying conduction in the free wall and septum to the anterior aspect of the right ventricle.

As shown by Rosenbaum,⁵⁵ Durrer et al.⁵⁶ and

Medrano et al.⁵⁷ the intraventricular septum is activated from the anterior and posterior divisions of the left bundle and not from its main stem. The present vectorcardiographic findings appear to indicate that, when the right bundle branch alone is blocked, the activation process in group A begins in the intact infero-posterior aspect; since there is an incomplete block on the anterior division of the left bundle or conduction delay on the anterior muscle, the segment of the right ventricular wall supplied by these propagation course will be activated later causing large vectorical forces oriented posteriorly, superiorly and to the right. However, in group A the forces are not larger than that in CRBBB with LAH, because in the former the direction of the mean QRS vector is usually not above minus 30 degrees.

The author and associates^{58,59} reported previously a concept of "critical corrected RR interval" in cases with intermittent bundle branch block, which appeared to be the dominant feature in determining the presence or absence of bundle branch block. It is suggested that the existence of "critical corrected RR interval" in subjects with intermittent CRBBB may be a clinical evidence of unidirectional spread of activation across the intraventricular septum and into the blocked ventricle in CRBBB.^{60,61} In isolated CRBBB, the portions of the specialized conduction system that remain viable for the transmission of a supraventricular depolarization are both fascicles of the left bundle. Accordingly,

when the activation spreads across the septum and into and through the blocked ventricle in isolated CRBBB, in author's opinion, relative conduction delay, irrespective of the anterior or infero-posterior wall, may occur in consequence of etiologic differences. The present case with intermittent group A and group B of isolated CRBBB suggests that both groups of isolated CRBBB may be due to the difference in impulse propagation created by disease.

At the present stage of knowledge, all that the author can say on the basis of electrogenesis are two groups of QRS complexes and five types of QRS-loop patterns. It is true that 15 (79%) of 19 subjects with hypertension and/or atherosclerosis had the type A type Ab and type ab QRS-loop patterns, and in the rest 4 subjects showing the type B QRS-loop pattern 2 cases were of variant type of angina pectoris. On the other hand, 6 of 7 subjects with chronic lung disease and 10 of 21 subjects with no evidence of cardiopulmonary disease showed the type aB and type B QRS-loop patterns.

The middle third of the right bundle is nourished almost exclusively by the anterior perforating branches of the left anterior descending artery,⁶² which is liable to hypertension and atherosclerosis.⁶³⁻⁶⁵ Slightly leftward deviation of $\dot{A}QRS$ may also develop simultaneously, since the anterior aspect of the septum and free wall is also supplied by the same main vessel (the anterior descending coronary artery).^{66,67} This speculation agrees well with the observations of *MacAlpin et al.*⁶⁸ and *Fernandez et al.*⁶⁹ They have reported that $\dot{A}QRS$ deviated leftward during selective left coronary artery opacification, whereas it deviated rightward during selective opacification of the right coronary artery. Therefore, the present two subjects with variant type of angina pectoris included in group B seem to be due to the injury to the right coronary artery.

Patient with advanced pulmonary disease, whether of the restrictive or obstructive type, may demonstrate RBBB and a tendency to RAD, that is group B. There is no denying the fact that in these cases group B has the same impulse propagation into and through the right ventricle as group A, since the tendency to RAD is the results of "verticalization" of the QRS forces due to diminished conductance of the lungs and the effect of a lowered diaphragm with or without coexisting cor pulmonale. It is admittedly purely speculative and must await further substantiation

that the significant difference in elevation of the spatial unblocked QRS vector between group A and group B is related directly to electrophysiologic events occurring with impulse propagation and not to the effect of anatomic position on axis.

*Grant*⁶⁶ reported that neither the severity of the left ventricular hypertrophy, nor the anatomic position of the heart in the chest, nor the body build of the patient played a significant role in the development of LAD. In the present study, therefore, the relationship between these factors and the incidence of both groups was not clarified.

As for the clinical correlation and vectorcardiographic findings, the author believes that muscle conduction delay in the anterior wall in group A of isolated CRBBB could probably result in a relatively early impulse propagation to the infero-posterior aspect of the ventricular septum and right ventricle. And also the varying vectorcardiographic patterns are likely to be related to variation in both the location and extent of the lesions involving the left and right bundle branch system, fiber muscle junctions and myocardium, respectively.

Vectorcardiography has been advocated when the electrocardiographic diagnosis of RVH may be unreliable, as in the presence of an rsR' in ECG lead V_1 and conduction disturbances.^{70,71} In such cases a CW loop in the horizontal plane is stated to indicate RVH. The specificity of such criteria for distinguishing RVH from RBBB or confirming RVH in the presence of RBBB is controversial, based on studies of patients with intermittent RBBB^{72,73} and experimentally induced RBBB⁷⁴ and RBBB aberrant ventricular conduction⁴ in normal subjects. Horizontal plane loops which were CCW during normal conduction became CW during RBBB or RBBB aberrant ventricular conduction. The results of the present study support the previous reluctance to accept a diagnosis of RVH on the basis of CW loop in the horizontal plane. Of the twelve subjects without chronic lung disease the horizontal plane loop was anterior to the E point with a wide CW loop in five and a figure-of-eight in the remainder (Fig. 6). It is of interest that 7 subjects had chronic lung disease, and all VCGs showed the I-1-B QRS-loop pattern except for one with hypertension displaying the I-3-A QRS-loop pattern. In some cases of type III, a combination with anterior block of left bundle is advocated by *Ueda et al.*⁴⁹ but *Toyama et al.*⁵⁰ suppose that

this type is caused by the block of the upper branch from their experiment.^{7,5} The author cannot agree with them from the author's experiment and it will be reported in another paper. In this study, the precise reasons for the varying vectorcardiographic patterns among types I, II and III remain unknown and require further study.

It has been suggested that RVH may be recognized by an increased amplitude of the secondary R wave in lead V_1 in the presence of RBBB.^{7,6} The present study confirms the opinion that a false-positive diagnosis may occur.^{4,7,7} In this study, eight subjects with no physical and roentgenologic evidence of RVH satisfied the criteria for RVH electrocardiographically (R' greater than 1.5 mV).

In the report by *Abildskov et al.*¹, the frontal QRS-loop in LVH with RBBB was described as being written in a CCW direction of inscription. But the author supposes that a false-positive diagnosis may occur since the frontal QRS-loops were CCW in the thirteen subjects with no physical and roentgenologic evidence of LVH. *Murata et al.*⁵ reported that the maximal T angle was concluded to be most useful for the diagnosis of LVH among various measurable parameters and to be frequently displaced further posteriorly, or sometimes posteriorly and to the right, in the presence of LVH.

As far as the diagnosis of associated ventricular hypertrophy is concerned, separate voltage criteria in R'_{V_1} , $R_1 + S_{III}$, R_{V_5} and R_{V_6} need not be set up in group A and group B, respectively (Table V).

Acknowledgement

The author is grateful for kind advice and criticism of Prof. Kiyowo Kosaka. The author's profound gratitude is also due to Assistant Prof. Shoichi Haraoka, without whose guidance and suggestions the present study would have been impossible.

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