True and False Left Anterior Hemiblock

Vectorcardiographic Study

Seiichi TOYAMA, M.D., and Keiko SUZUKI, M.D.

SUMMARY

For confirming the configuration of the QRS loop in left anterior hemiblock, 82 cases with the frontal QRS vector above minus 30 degrees were collected and classified by the configuration of the horizontal QRS loop. Thereafter, a comparison has been made between the configuration of the QRS loop in clinical cases and that in the authors' construction method, and the following findings for criteria of left anterior hemiblock are obtained.

- 1) The afferent limb of the frontal QRS loop is dislocated to the left and more superiorly.
- 2) The efferent and afferent limbs of the horizontal QRS loop are located left posteriorly. The configuration of the horizontal QRS loop is long and narrow and the direction of inscription is clockwise, a figure of 8 or counterclockwise.
- 3) Cases with the right posterosuperior dislocation of the afferent limb of the QRS loop is excluded from left anterior hemiblock.

Additional Indexing Words:

Left anterior hemiblock Marked left axis deviation Afferent limb of the QRS loop

SINCE Rosenbaum¹⁾ reported the characteristic findings of left anterior and posterior hemiblock in the electrocardiogram, many investigators have been interested in the electrocardiographic and vectorcardiographic criteria of hemiblock.

The criteria of left anterior hemiblock in the electrocardiogram were reported by Rosenbaum,¹⁾⁻³⁾ Pryor,⁴⁾ and other investigators. Benchimol⁵⁾ and his coworkers described the vectorcardiographic findings in cases which satisfied Rosenbaum's criteria in the electrocardiogram. Medrano et al⁶⁾ mentioned the vectorcardiographic criteria based on their experimental study in dogs.

It is well known that one of the criteria of left anterior hemiblock in the electrocardiogram is the marked left axis deviation. Therefore, one is often

From the Department of Cardiology, Center for Adult Diseases, Osaka, 3-3 Nakamichi 1-chome, Higashinari-ku, Osaka 537, Japan.

Received for publication September 18, 1975.

tempted to make a diagnosis of left anterior hemiblock with marked left axis deviation.

However, Rosenbaum himself proposed 3 criteria which were reported in 1967, 1969, and 1970 and the degrees of the frontal QRS vector in left anterior hemiblock were different in his 3 criteria. Benchimol adopted Rosenbaum's first criteria, and Medrano described 2 different configurations of the QRS loop in his vectorcardiographic criteria. Therefore, the electrocardiographic and vectorcardiographic criteria of left anterior hemiblock were confusing, and, it is questionable whether the criteria proposed by these investigators are adequate.

In order to re-examine these criteria, the authors collected cases with the frontal QRS vector above minus 30 degrees, and these cases were divided into 4 groups depending on the configuration of the horizontal QRS loop in the vectorcardiogram. Then, a comparison was made between the configuration of the QRS loop in these clinical cases and that in the construction method with a computer. The adequate vectorcardiographic criteria of left anterior hemiblock were discussed.

MATERIALS AND METHODS

In patients whose vectorcardiograms with the Frank system were recorded in Center for Adult Diseases, Osaka, 82 cases with the frontal QRS vector above 30 degrees in the electrocardiogram were collected. In all cases, the duration of the QRS wave was less than 0.12 sec. These cases were divided into the following 4 groups.

Group 1. The afferent limb of the horizontal QRS loop was located left posteriorly and the direction of inscription of the horizontal QRS loop was a figure of 8 or clockwise.

Group 2. The afferent limb of the horizontal QRS loop was located left posteriorly and the direction of inscription of the horizontal QRS loops was counterclockwise.

Group 3. The afferent limb of the horizontal QRS loop was located posteriorly and the direction of inscription of the horizontal QRS loop was counterclockwise.

Group 4. The afferent limb of the horizontal QRS loop was located right posteriorly and the direction of inscription of the horizontal QRS loop was counterclockwise.

In these cases, the main portion and the afferent limb of the frontal QRS loop were located superiorly.

The construction method of the QRS loop with a computer was as follows.⁷⁾ The right and left ventricles including the ventricular septum were divided into 14 segments; namely, the inferior and superior segments of the anterior wall, the lateral wall, and the posterior wall in both ventricles (Lai, Las, Lmi, Lms, Lpi, Lps, Rai, Ras, Rmi, Rms, Rpi, and Rps) and the septum of the left and right ventricles (LS and RS). The direction and time course of each segment were assumed and each

Fig. 1. Group 1. Case 1.

Fourteen years before, he had an attack of myocardial infarction. The efferent and afferent limbs of the horizontal QRS loop were dislocated left posteriorly. The direction of inscription was a figure of eight. The afferent limb of the frontal QRS loop was located left superiorly.

value was in-put into a computer. After the calculation with a computer NEAC 2200, the QRS loops in 3 planes were drawn with the X-Y plotter.

RESULTS

1. Clinical cases

Group 1

Case 1. S. S., 52-year-old male (Fig. 1)

Fourteen years before, he had severe anginal attack and was diagnosed as anterior infarction. His electrocardiogram showed QS pattern in V 1-3 and qrSr's' pattern in V4. In the limb leads, the deep S wave was observed in lead II, III, and aVF.

In the vectorcardiogram, the frontal QRS loop was located markedly left superiorly and the angle of the maximal QRS vector was -37 degrees. In the horizontal QRS loop, the efferent limb was directed left posteriorly and the direction of inscription was a figure of 8.

Fig. 2. Group 1. Case 9.

The horizontal QRS loop was initiated right anteriorly, but the efferent and afferent limbs of the horizontal QRS loop were dislocated left posteriorly with a figure of eight. The afferent limb of the frontal QRS loop was also located left superiorly.

Case 9. T. H., 37-year-old male (Fig. 2)

Sometimes he complained of chest pain. In his electrocardiogram, rS pattern was found in V 1-3 and rR'S' pattern in V 4. The QRS wave in II, III, and aVF showed the deep S wave.

The frontal QRS loop was located mainly left superiorly. In the horizontal plane, the initial QRS loop was directed right anteriorly, but the efferent and afferent limbs were located left posteriorly. The direction of inscription was a figure of 8.

Nine cases belonged to this group. The direction of inscription of the horizontal QRS loop was a figure of 8 in 5 cases and clockwise in 4 cases. The main portion of the frontal QRS loop in this group was located left superiorly. In the electrocardiogram, QS pattern in V 3-4 was observed in 5 cases.

Group 2

Case 10. T. M., 50-year-old male (Fig. 3)

Fig. 3. Group 2. Case 10.

The horizontal QRS loop was initiated right anteriorly, but the efferent and afferent limbs were dislocated left posteriorly with counterclockwise inscription.

His electrocardiogram showed marked left axis deviation. In the precordial leads, rS pattern in V1-2 and QS pattern in V3 were found. The main portion of the frontal QRS loop was located left superiorly similar to Case 9 of Group 1. In the horizontal QRS loop, the afferent limb was located left posteriorly and the direction of inscription was counterclockwise.

In this group, 5 cases showed QS pattern and other 3 cases rS or QRS pattern in V3.

In the horizontal QRS loop, the direction of inscription was counterclockwise and the configuration was long and narrow. In 1 case with RS pattern in V3, the efferent limb was initiated left anteriorly and then directed left posteriorly. The configuration of this case was similar to that in left ventricular hypertrophy. In the frontal QRS loop, the initial QRS loop was directed left inferiorly except in 1 case, but the main QRS loop was located left

Fig. 4. Group 3-A. Case 19.
The horizontal QRS loop was initiated right anteriorly, but the efferent limb was directed left posteriorly. The afferent limb was located posteriorly.

superiorly. One case showed the complete superior displacement of the QRS loop (Toyama-Suzuki's syndrome³⁾).

Group 3

In this group, the afferent limb of the horizontal QRS loop was located posteriorly. This group could be divided into A and B subgroups depending on the location of the efferent limb.

Group 3-A

The efferent limb was located mainly left posteriorly.

Case 19. H. M., 68-year-old male (Fig. 4)

His blood pressure was 200/80 mmHg. He complained of shortness of breath on effort. His electrocardiogram showed marked left axis deviation and rSr' pattern in V 1-3. In the vectorcardiogram, the initial vector of the horizontal QRS loop was directed right anteriorly. However, the efferent limb was dislocated left posteriorly and the afferent limb was located posteriorly. The afferent limb of the frontal QRS loop was located superiorly.

In 3 cases out of 5 in Group 3-A, the abnormal Q wave was found in

Fig. 5. Group 3-B. Case 18.

The efferent limb of the horizontal QRS loop was located left anteriorly, and the afferent limb was located posteriorly.

V 2-4, and the configuration of the frontal QRS loop in 4 cases was similar to that of Case 19. Only in 1 case, the frontal QRS loop was initiated right inferiorly and then directed left inferiorly. However, the main portion was located right superiorly and the direction of inscription was clockwise.

Group 3-B

The efferent limb of the horizontal QRS loop was located left anteriorly.
Case 18. Y. I., 63-year-old male (Fig. 5)

He complained of tightness of breast on effort for 10 years. His electrocardiogram showed rS pattern in V 1-3 and RS pattern in V 4. The QRS in aVF was rS pattern, but S wave was not so deep. In the vectorcardiogram, the horizontal QRS loop was initiated right anteriorly and the efferent limb was located left anteriorly. The afferent limb was posteriorly. In the frontal QRS loop, the efferent limb was located to the left and the afferent limb was located left superiorly and superiorly.

In 6 cases of Group 3-B, the direction of inscription of the frontal QRS

Fig. 6. Group 4. Case 30.

The efferent limb of the horizontal QRS loop was located leftward and slightly anteriorly, and the afferent limb was located left posteriorly to right posteriorly.

loop was counterclockwise in 4 cases and a figure of 8 in 2 cases.

Group 4

In this group, the afferent limb of the horizontal QSR loop was located right posteriorly. The efferent limb was located left anteriorly in most cases and located left posteriorly in a few cases. In the frontal QRS loop, the efferent limb was located left inferiorly in most cases and the afferent limb was located right superiorly in all cases. However, the degree of the superior location of the afferent limb was different. Therefore, this group could be divided into 2 subgroups; namely marked and mild superior location.

Case 30. S. K., 60-year-old male (Fig. 6)

He complained of chest pain and dizziness. His electrocardiogram showed marked left axis deviation, and rS pattern in V 1-4 and qRS pattern in V 4 were observed. In the horizontal QRS loop, the afferent limb was located left anteriorly and the afferent limb was located from left posteriorly to right posteriorly. In the frontal plane, the afferent limb was located left

Fig. 7. The QRS loop of the authors' construction method with a computer.

a) Normal QRS loop. b) The depolarization process of Laid and Las was delayed 20 msec.

Fig. 8. The horizontal QRS loop in a clinical case was similar to that of Fig. 7-b.

In this case, the frontal QRS loop was not dislocated so superiorly as that in Group 1.

Fig. 9. The depolarization process of Lai and Las was delayed and prolonged with the leftward and upward shift of the vector.

a) 30 degrees. b) Leftward 30 degrees and upward 60 degrees.

superiorly to right superiorly, but the superior location was not so marked.

In lead I of this group, qR pattern was found in 16 cases, qRs pattern in 17 cases, Rs pattern in 15 cases and rS pattern in 6 cases. Namely, total number of this group was 54 cases. On the contrary, total number of Group 1-3 was only 28 cases.

In the vectorcardiogram of this group, the rightward dislocation of the afferent limb of the QRS loop was more remarkable in cases with rS pattern in lead I than in cases with other QRS pattern. In most cases, the direction of inscription of the horizontal and frontal QRS loop was counterclockwise, but in some cases with rS pattern in lead I, the direction of inscription was clockwise.

2. The construction method of the QRS loop with a computer

1) The normal QRS loop

As shown in Fig. 7-a, the configurations of the QRS loop in 3 planes were similar to those in clinical normal cases.

2) When the depolarization of the anterior wall of the left ventricle was delayed with the normal depolarization process (the direction of the vector in Lai and Las was unchanged), the efferent limb of the horizontal QRS loop was dislocated left posteriorly and the afferent limb more left anteriorly than that in the normal QRS loop. Then, the direction of inscription was a figure of 8. In the frontal QRS loop, the afferent limb was also dislocated more superiorly, but the degree was mild (Fig. 7-b). The QRS loops in 3 planes were similar to those in the clinical case of Fig. 8.

3) When the depolarization of Lai and Las was delayed 20 msec with prolonged depolarization process and the leftward and upward shift of the vectors (30 degrees), the efferent limb of the horizontal QRS loop was dislocated left posteriorly and the afferent limb left anteriorly. The direction of inscription was a figure of 8. The superior dislocation of the afferent limb of the frontal QRS loop was more marked than that in the former case (Fig. 9-a).

4) When the vectors of Lai and Las were shifted more superiorly with delayed and prolonged depolarization, the horizontal QRS loop was very narrow and located left posteriorly with counterclockwise inscription. The superior dislocation of the frontal QRS loop was marked (Fig. 9-b).

5) On the contrary, when the depolarization of the posterior wall in the left ventricle (Lpi and Lps) was delayed 10 msec and prolonged with the right superior shift of the vector, the efferent limb of the horizontal QRS loop was located left anteriorly and the afferent limb right posteriorly. In the frontal plane, the efferent limb of the QRS loop was directed to the left and the afferent limb was dislocated right superiorly. The configurations of the QRS

Fig. 10. The depolarization process of Lpi and Lps was delayed 10 msec with the right superior shift of the vectors.

loop in 3 planes were similar to those in Group 4, but were different from those in Groups 1 and 2 (Fig. 10).

DISCUSSION

Rosenbaum¹⁾ described that marked left axis deviation had a close correlation to left anterior hemiblock, and proposed 3 criteria of left anterior hemiblock. In his first criteria of 1968,¹⁾ the direction of the QRS axis in the frontal plane was above minus 45 degrees. In the second criteria of 1969,²⁾ the mean QRS force was at about minus 60 degrees. In 1970³⁾, he divided left anterior hemiblock into 4 types; namely, type I, II, III, and IV. In these types, the direction of the mean QRS axis was not constant. It was from -45 to -60 degrees in Type I, from -75 to -80 degrees in Type III, and about -60 degrees in Type IV.

However, which of those criteria is adequate to make a diagnosis of left anterior hemiblock? On what grounds did he establish his criteria?

The QRS loop does not show the same configuration, even if its mean frontal QRS axis is the same. In the authors' clinical cases with marked left axis deviation, the configuration of the QRS loop in Group 4 is completely different from those in Groups 1 and 2. Therefore, this problem does not seem to be discussed by the electrocardiogram, so that the vectorcardiographic findings are adopted in discussing the criteria of left anterior hemiblock in this study.

Benchimol et al⁵⁾ reported the configurations of the QRS loop in left anterior hemiblock. However, he simply collected cases whose electrocardiograms satisfied Rosenbaum's first criteria. Therefore, his configurations of the QRS loop are not useful to discuss the vectorcardiogram of left anterior hemiblock.

Medrano et al⁶⁾ described the vectorcardiographic criteria based on his experimental study and reported 2 configurations of the QRS loop; namely

that of vertical heart and of horizontal heart.⁶⁾ In the former, the QRS loop is similar to that of Group 1 in the authors' cases, and the latter to that of Group 4.

In the authors' cases with marked left axis deviation, the QRS loop in Groups 1 and 2 is located left posterosuperiorly, but that in Group 4 is located left anteroinferiorly to right posterosuperiorly. The locations and configurations of the QRS loop in Groups 1 and 2 are quite different to those in Group 4.

Is it possible to consider that these 2 different QRS loops are produced by the same origin—left anterior hemiblock?

Madrano illustrated that the difference was due to the heart position (vertical and horizontal). However, in the electrocardiogram and X-ray film of Japanese people, cases with the vertical heart position are more frequently observed than those with the horizontal heart position, but Group 4 which is similar to a case of left anterior hemiblock with the horizontal heart position by Medrano et al is found 3 times as often as Groups 1 and 2 which are similar to a case with the vertical heart position. Consequently, it is questionable to admit their explanation.

It can be considered that the excitation of the anterior wall in the left ventricle is delayed in left anterior hemiblock. In the authors' construction method of the QRS loop with a computer, when the depolarization process of the anterior wall in the left ventricle is delayed with the more left superior direction of the vector due to abnormal process, the QRS loop is dislocated left posterosuperiorly and is similar to that in Groups 1 and 2 as shown in Fig. 9. Therefore, it is easily understood that the QRS loops in Groups 1 and 2 are produced by left anterior hemiblock, and that the horizontal QRS loops of left anterior hemiblock reported by Rosenbaum^{2),3)} were similar to that in Groups 1 and 2. But, it is impossible to construct the QRS loop similar to that in Group 4 with the abnormal depolarization process of the anterior wall in the left ventricle.

Sodi-Pallares explained that in the QRS loop of the horizontal heart, the left anterior location of the efferent limb was mainly due to the excitation of the anterior septum. However, it is very difficult to consider that the vector of the anterior septum of the right ventricle is so powerful as to overcome the other vectors and to take the initiative in determining the left anterior location of the efferent limb of the QRS loop. Moreover, he insisted that the delayed excitation of the anterior septum and the upper area of the anterolateral wall was directed right posterosuperiorly. But it is very difficult to consider such direction of the vector, even though the heart position is horizontal.

In the authors' method, when the depolarization process of the posterior

wall in the left ventricle is slightly delayed with the right posterosuperior direction of the vector, the QRS loops in 3 planes are very similar to those in Group 4 as shown in Fig. 10. The reason why such abnormal depolarization process of the posterior wall is produced remains to be studied. But, the superior area of the posterior wall is excited lastly in normal subjects, and cases with the right posterosuperior location of the terminal portion of the QRS loop are often observed. Therefore, it can be considered that the QRS loop in Group 4 is more extreme cases in such condition.

The QRS loop in Group 3-B is similar to that in Group 4 except the slight leftward location of the afferent limb, and it can be said that Group 3-B belongs to the same class as Group 4.

Finally, the authors should like to propose the following vectorcardiographic criteria of left anterior hemiblock.

1. The (marked) left superior dislocation of the afferent limb of the frontal QRS loop.

2. The efferent limb and the afferent limb of the horizontal QRS loop are located left posteriorly, and the configuration of the horizontal QRS loop is long and narrow. The direction of inscription of the QRS loop is clockwise, a figure of 8 or counterclockwise.

Of course, it is necessary to exclude the abnormal QRS loop due to marked left ventricular hypertrophy, because in cases with aortic insufficiency the direction of inscription of the horizontal QRS loop is often a figure of 8 and is similar to that of left anterior hemiblock. But the afferent limb of the frontal QRS loop is not dislocated so superiorly.

REFERENCES

1. Rosenbaum MB, Elizari MV, Lazzari JO: Los Hemibloques. Buenos Aires, Paidós, 1968
2. Rosenbaum MB: Types of left bundle branch block and their clinical significance. *J Electrocardiol* **2**: 197, 1969
3. Rosenbaum MB: The hemiblocks. Oldsmoor, Florida, Tampa Tracing, 1970
4. Pryor R, Blount SG: The clinical significance of true left axis deviation. Left intraventricular blocks. *Am Heart J* **72**: 391, 1966
5. Benchimol A, Barreto EO, Pedraza A: The Frank vectorcardiogram in left anterior hemiblock. *J Electrocardiol* **4**: 116, 1971
6. Medrano GA et al: Clinical electrocardiographic and vectorcardiographic diagnosis of the left anterior subdivision block isolated or associated with RBBB. *Am Heart J* **83**: 447, 1972
7. Toyama S, Suzuki K: The construction method of the QRS loop in myocardial infarction. *Jap Heart J* **17**: 180, 1976
8. Toyama S, Suzuki K: Cases with a complete superior displacement of the QRS loop (Toyama and Suzuki's syndrome). *Jap Circulat J* **32**: 1439, 1968