Electrocardiographic Criteria of Left Ventricular Hypertrophy in the Presence of Left Bundle Branch Block

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SUMMARY

When left bundle branch block (LBBB) is present on the electrocardiogram, the diagnosis of left ventricular hypertrophy (LVH) may be difficult. The left ventricular mass in 70 patients with LBBB was estimated by echocardiography, and was compared to the QRS configuration on the electrocardiogram. We found that there was agreement between a monophasic R pattern in lead I or V_6 (sensitivity 79.3%, 70.7%) and left ventricular hypertrophy. We suggest that a monophasic R pattern in L_1 and V_6 may provide a useful simple index of left ventricular hypertrophy in the presence of left bundle branch block.

Additional Indexing Words:

Left ventricular hypertrophy Left bundle branch block M-mode echocardiography

THE presence of left bundle branch block (LBBB) makes the electrocardiographic diagnosis of left ventricular hypertrophy (LVH) difficult. While some authors believe that the electrocardiographic voltage criteria for left ventricular hypertrophy apply in the presence of LBBB, others suggest that the diagnosis of LVH may be unreliable.¹⁾⁻⁵⁾ Echocardiography is an accurate method of assessing left ventricular mass (LVM).^{6), 7)}

We have studied the echocardiographic features of 70 patients with LBBB on their ECG, and compared the results with their QRS configurations.

PATIENTS AND METHODS

Patient selection:

Of 3,415 patients who had ECGs recorded at our clinic between October 1983 and October 1987, 83 were identified as having complete LBBB. Only 70 patients could be recalled for echocardiography and a repeat electrocardiogram. Eleven of the 70 patients were clinically normal, 35 had suspected

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coronary artery disease, 14 had hypertension, 5 had valvular heart disease and 5 had idiopathic cardiomyopathy. The patients ranged in age from 28–83 years (average 61 years) and included 34 men and 36 women. Another group of 30 clinically normal subjects with normal electrocardiograms was examined to establish a normal value for left ventricular mass. We also examined another group of 30 subjects with echocardiographically hypertrophic left ventricles and normal conduction.

All electrocardiograms were recorded with a Cambridge chart using multichannel simultaneous leads. All of the following criteria were required for the diagnosis of complete LBBB.^{8)–10)}

1. Documented atrioventricular conduction.
2. Absence of the Wolff-Parkinson-White syndrome.
3. QRS duration of 120 ms or longer.
4. Slurred R wave in leads 1, aV_R and V₆ and broad, slurred S wave in V₁ and V₂ (QS or rS).
5. Absence of Q waves in any left heart lead.
6. ST segment depression and/or T wave inversion in the left precordial lead.
7. R wave inversion in the left precordial leads (particularly leads 1 and V₆).

All ECGs were coded by one investigator (BK) who had no knowledge of the echocardiographic results. The R and S waves of all 12 leads were carefully measured and recorded, averaged where necessary to the nearest 0.1 mV or mm. The following information was also recorded from the ECGs^{8),11)}: height (mV) of waves in leads 1, 2, 3, aV_R, V₁ and V₆ as well as S wave depth in any lead and the presence or absence of left atrial abnormality.

Echocardiography:

M-mode left ventricular echocardiograms were obtained with an Echo IV Honeywell instrument using a 2.5-MHz transducer at a paper speed of 50 mm/sec.

Left ventricular echocardiograms were measured at or just below the level of the mitral leaflets, in areas of the recording that showed the largest left ventricular internal dimension (LVIDd). The left ventricular septal and posterior wall dimensions were measured at the peak of the R wave of a simultaneously recorded electrocardiogram (Fig. 1). Left ventricular internal dimension (LVIDd), posterior wall thickness (PWT) and septal thickness (ST) were identified using the “pen convention measurement” regression corrected “cube formula”,⁷⁾ and using this formula, left ventricular hypertrophy was defined as left ventricular mass ≥ 215 g.

The echocardiographic features of the patients were divided into 5 groups

Fig. 1. M-mode echocardiogram. Pen convention measurement.

as follows¹²⁾:

1. Normal left ventricular dimension and wall thickness.
2. Concentric left ventricular hypertrophy ($ST + PWT \geq 26$ mm, $ST/PWT \leq 1.3$ and $LVIDd \leq 55$ mm).
3. Asymmetric septal hypertrophy ($ST \geq 15$ mm, $ST/PWT \geq 1.3$, $LVIDd \leq 55$ mm).
4. Dilated left ventricle ($LVIDd \geq 55$ mm).
5. Dilated and hypertrophied left ventricle ($ST + PWT \geq 26$ mm, $ST/PWT \leq 1.3$, $LVIDd \geq 55$ mm).

Statistical methods:

The sensitivity and specificity of the various electrocardiographic criteria for left ventricular hypertrophy were calculated using standard formulae:

$$\text{Sensitivity (\%)} = \frac{\text{True positives correctly diagnosed}}{\text{Total true positives}} \times 100$$

$$\text{Specificity (\%)} = \frac{\text{True negatives correctly diagnosed}}{\text{Total true negatives}} \times 100$$

RESULTS

Technically satisfactory echocardiograms were obtained in all patients. The left ventricular mass exceeded 215 g in 58 of 70 patients (82.8%), mean left ventricular mass was 342 ± 49 g (range 132–710 g) (Table I).

The sensitivity and specificity of the various electrocardiographic parameters for the detection of left ventricular hypertrophy are listed in Table II. Several criteria ($R_1 + S_3 \geq 25$ mV, $RaV_L \geq 11$ mV, $R_1 \geq 20$ mV, $R_1 + S_3 \geq 17$ mV, $RV_{5-6} \geq 25$ mV and left axis ≥ -30) were associated with 100% specificity but suffered from a lack of sensitivity. Of all ECG criteria examined, the presence of the deepest S+tallest R ≥ 35 mV and left atrial abnormality (enlargement) were the best overall predictors of left ventricular hypertrophy in the presence of left bundle branch block.

Tables III and IV provide the sensitivity and specificity of various electrocardiographic parameters and QRS pattern in the diagnosis of left ventricular hypertrophy as compared to a diagnosis of left ventricular hypertrophy by echocardiography. Good overall single parameters were a monophasic R in lead 1 (sensitivity 79.3%, specificity 100% and a monophasic R in lead V_6 (sensitivity 70.7%, specificity 100%). The rSR pattern in L_1 was

Table I. Mean Left Ventricular Mass in Normal Subjects, Hypertrophic Subjects with Normal Conduction and Patients with Left Bundle Branch Block

	Normal M-mode mass (g)	Hypertrophy with normal conduction M-mode mass (g)	Left BBB M-mode mass (g)
Women	(n=17) 126.2 $\pm$ 17	(n=10) 317.4 $\pm$ 32	(n=36) 309.2 $\pm$ 54
Men	(n=13) 147.3 $\pm$ 30	(n=20) 381.6 $\pm$ 17	(n=34) 336.5 $\pm$ 33
Total	(n=30) 138.4 $\pm$ 21	(n=30) 354.0 $\pm$ 23	(n=70) 342.1 $\pm$ 49

Table II. The Percentage Specificity and Sensitivity of Various ECG Measurements of Left Ventricular Hypertrophy in Left BBB

Parameters	Specificity (%)	Sensitivity (%)
$R_1 + S_3 \geq 25$ mV	100	22.4
$RaV_L \geq 11$ mV	100	13.8
$R_1 \geq 20$ mV	100	5.2
$(R_1 + S_3) - (S_1 + P_s) \geq 17$ mV	100	13.8
$SV_1 + RV_{5-6} \geq 35$ mV	83.3	65.5
Deepest S+Tallest R ≥ 35 mV	58.3	70.7
$RV_{5-6} \geq 25$ mV	100	12.1
Left axis ≥ -30	75	70.7
Left atrial abnormality	75	41.5

Table III. Electrocardiographic QRS Pattern in Patients with Left BBB

QRS pattern	Specificity (%)	Sensitivity (%)
Monophasic R in L ₁	100	79.3
V ₆	100	70.7
rR pattern in L ₁	66.7	8.6
V ₆	75	6.9
Rr pattern in L ₁	75	13.8
V ₆	58.3	8.6
RR pattern in L ₁	66.7	8.6
V ₆	16.7	3.4
rSR pattern in L ₁	91.7	1.7
V ₆	16.7	1.7
Other patterns	—	—

Table IV. Relation of Echocardiographic Left Ventricular Abnormalities and ECG Pattern Criteria of Left BBB

QRS pattern	Echocardiographic status (%)				
	Type 1 n=12	Type 2 n=16	Type 3 n=5	Type 4 n=16	Type 5 n=21
Monophasic R in L ₁	—	75	60	87.5	76.2
V ₆	—	62.5	60	93.7	61.9
rR pattern in L ₁	33.3	12.5	20	—	9.5
V ₆	25.0	6.2	20	6.2	4.8
Rr pattern in L ₁	25.0	25	20	6.2	9.5
V ₆	41.6	12.5	—	6.2	9.5
RR pattern in L ₁	33.3	—	—	—	19
V ₆	16.7	6.2	20	—	—
rSR pattern in L ₁	8.4	—	—	—	4.8
V ₆	16.7	—	—	—	4.8

very specific (91.7%), but low in sensitivity (1.7%) (Fig. 2).

Using the echocardiographic left ventricular dimension and thickness, various combinations of criteria were selected from Table IV. A monophasic R in lead 1 was present in 87.5% in type 4 and a monophasic R in V₆ was present in 93.7% in type 4.

DISCUSSION

Our results demonstrate a high prevalence (83%) of left ventricular hypertrophy in a general hospital population with left bundle branch block. This strong association of left ventricular hypertrophy with left bundle branch block has been noted by others.^{3),4),13)}

Petersen et al²⁾ found that 80% of patients with LBBB had left ventricular hypertrophy as determined from measured left ventricular wall thickness, but only 14 had electrocardiographic evidence of this, while 2 of the 10 patients without left ventricular hypertrophy had positive electrocardiographic criteria. Twenty six of 40 patients with anatomic left ventricular hypertrophy did not have electrocardiographic evidence of this.

Lopez et al¹⁴⁾ studied 30 patients with LBBB by means of M-mode echocardiography and calculated the left ventricular mass. In 23 patients with an abnormal left ventricle, the left ventricular mass averaged 241 ± 12 g. The Sokolow-Lyon score diagnosed 19 of 23 (82%) with 2 false positive results. Recently, Noble et al used echocardiography to determine the prevalence of anatomic left ventricular hypertrophy in 28 patients with LBBB.¹³⁾ They found anatomic left ventricular hypertrophy in 89% of their patients and left atrial abnormality was detected in 58% with 100 specificity. Our sensitivities and specificities of the individual variables in the detection of left

Fig. 2. Example of electrocardiographic QRS pattern.

Table V. Comparison of Selected ECG Criteria for Left Ventricular Hypertrophy

	Present study Left BBB, LV mass ≥ 215 g Sens/Spec	Present study Normal con- duction, LV mass ≥ 215 g Sens/Spec	Kafka ¹⁶⁾ study Left BBB, LV mass ≥ 215 g Sens/Spec	Reichek ⁷⁾ Normal con- duction, LV mass ≥ 215 g Sens/Spec
$RaV_L \geq 1$	22.4/100	20/100	21/89	47/99
$SV_1 + RV_{5-6} \geq 35$	65.5/83.3	77/70	55/73	53/86
Left atrial abnormality	41.5/75	48/80	41/98	47/91
Left axis ≥ 30	70.7/75	14/100	30/75	33/97
Monophasic R in L_1	79.3/100	—	—	—
V_6	70.7/100	—	—	—

ventricular hypertrophy are similar to those reported by others^{3),4),13),15)} (Table V). This confirms that ECG criteria are as valid in the presence of left LBBB as they are in patients with normal conduction.

Most previous studies have used only individual electrocardiographic variables and never used QRS configuration. We found a good agreement between a monophasic R pattern in lead I and V₆. A monophasic R pattern in lead I was present in 85.7% of patients with dilated ventricles. Also, 93.7% of patients with type 4 (dilated left ventricle) had a monophasic R pattern in V₆. The best overall single parameter was a monophasic R in lead I (specificity 100%, sensitivity 70.7%). We suggest that these criteria may provide a useful index of left ventricular hypertrophy in the presence of left bundle branch block.

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