Peer reviewed article

Diagnostic accuracy of exercise electrocardiogram in patients with left anterior hemiblock

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Summary

Background: Left anterior hemiblock (LAHB) is the most frequent conduction abnormality, but its impact on the diagnostic accuracy of the exercise ECG has not been studied. The aim of our study was to determine the diagnostic accuracy of ST depression for predicting ischaemia in the presence of LAHB.

Patients: Consecutive patients with known or suspected coronary heart disease undergoing exercise ECG and 99mTc-sestamibi single photon emission computed tomography (SPECT) were included in the analysis. Patients with left bundle branch block, with changes in QRS morphology related to myocardial infarction, and patients who had undergone pharmacological stress testing were excluded.

Results: Of 1532 patients assessed, 567 patients qualified for the analysis. In 69 patients with LAHB, ECG stress testing had lower sensitivity (38% *vs* 86%) and lower negative predictive value (82% *vs* 92%) than in patients with normal baseline ECG. The reduction of sensitivity appeared to be similar in patients with isolated LAHB (n = 43), in patients with right bundle branch block (n = 39), and with bifascicular block (n = 26). In contrast, the positive predictive value of the test was excellent.

Conclusion: The diagnostic accuracy of the exercise ECG for prediction of ischaemia is reduced in patients with LAHB.

Key words: ischaemia; ECG stress test; scintigraphy; left anterior hemiblock; test accuracy

Introduction

The exercise electrocardiogram (ECG) is widely used to evaluate patients with known or suspected coronary artery disease, and exercise-induced ST segment depression is a reliable marker of myocardial ischaemia. However, the diagnostic accuracy of the ST segment response to exercise is altered in patients with baseline ECG abnormalities [1]. For example, left bundle branch block and a paced ventricular rhythm hamper interpretation of the test [1, 2]. Also, the diagnostic value of the exercise ECG is lowered in patients with left ventricular hypertrophy, in patients with preexcitation, and in patients with abnormal repolarisation in the resting ECG. In the presence of right bundle branch block (RBBB) test sensitivity is decreased [1, 3–7]. The effect of left anterior hemiblock (LAHB) on ECG diagnosis of stressed induced ischaemia has not been analysed to date.

The purpose of this investigation was to determine whether ST depression during exercise stress testing can accurately predict the prevalence of ischaemia in patients with LAHB.

Methods

Conflict of interest: None.

Source of support: None.

Patients

Consecutive patients with known or suspected coronary artery disease who underwent exercise electrocardiogram and 99mTc-sestamibi single photon emission computed tomography (SPECT) were included in a retrospective analysis. Patients with left bundle branch block, left posterior hemiblock, non-specific intraventricular conduction disturbances, QRS alterations post myocar-

dial infarction or with inadequate-quality exercise ECG tracings were excluded, as were patients who had undergone pharmacological stress testing with dipyridamole.

The criteria for LAHB were a leftward QRS axis of –30° to –90°, rS pattern in leads II, III, aVF and a deep Q wave in aVL, with normal QRS duration [8]. Criteria for LAHB combined with RBBB additionally included the presence of a typical rSR' pattern in V1 with a QRS width of 120 msec or more.

Exercise ECG

All patients underwent a symptom-limited upright bicycle ergometry test. Treatment with beta-blocker or digoxin was stopped four days before the test. Blood pressure was measured every two minutes using the Riva-Rocci method. Three ECG leads were monitored continuously. A 12-lead ECG was recorded at rest and every minute until the end of the recovery phase. All ECG printed at a paperspeed of 25 and 50 mm/sec were analysed manually. An ischaemic response was defined as ≥0.1 mV horizontal or downsloping ST segment depression compared with baseline in at least two adjacent leads in V4–V6, measured 80 ms from the J point at heart rate <130 bpm, and 60ms from the J point at heart rate ≥130 bpm.

SPECT imaging

SPECT imagings at rest and post-exercise (symptom-limited) were performed at least 48 hours apart. Treatment with beta-blocker was stopped four days before the test. Approximately one minute before termination of the exercise stress test an intravenous dose of 99m technetium methoxy isobutyl isonitrile sestamibi was given. A dose of 1 GigaBq was given to patients weighing 75 kg or over and of 800 MBq to patients weighing less than 75 kg. Stress images were acquired 30 minutes after termination of the test using a PRISM 3000 gammarecorder (Picker). For resting studies the same isotope was injected 24 hours after the stress study, and resting images were recorded 60 minutes after injection. For each study six oblique (short axis) slices from the apex to the base and three sagittal (vertical long axis) slices from the septum to the lateral wall were defined. Each of the six short axis slices was divided into eight equal segments. The scan was interpreted semiquantitatively by visual analysis assisted by circumferential profile analysis. Myocardial perfusion was assessed by measuring the area between the lower limit of normal values (±2 SD) and the actual circumferential profile of the patient on rest and stress images. Stress and rest tomographic views were reviewed side by side by an experienced observer who was unaware of stress-induced ECG abnormalities or angiographic data. A reversible perfusion defect was defined as a perfusion defect on stress images which partially or completely resolved at rest in two or more contiguous segments or slices. A fixed perfusion defect was defined as a perfusion defect on stress images in two or more contiguous segments or slices which persisted on rest images.

Statistical analysis

Continuous data were expressed as mean values ± SD. Comparisons between categorical variables were analysed using the chi-square test. Quantitative variables were compared using analysis of variance (ANOVA). Differences were considered significant at a p value of <0.05, whereas statistical significance levels were adapted in line with Bonferroni's correction in between-group comparisons of continuous variables.

Results

Patient characteristics and ECG

Of 1532 consecutive patients screened, 965 were excluded. The reasons for their exclusion are shown in table 1.

The study population consisted of 567 patients, including 69 with LAHB, 39 with RBBB, and 459 without baseline ECG abnormalities. The clinical characteristics of the patients are detailed in table 2.

Of the 69 patients with LAHB, 43 (62%) had isolated LAHB and 26 had LAHB associated with RBBB. Of the 43 patients with isolated LAHB, 25 (58%) had an rS complex (r<S) in V5–6, and 18 (32%) had an Rs complex (R≥s wave) in V4–6. Of the 26 patients with LAHB and RBBB, only 4 (15%) had an Rs complex in V4–6.

Table 1

Reasons for exclusion.

Exclusion criteria	Number of patients (%)
Myocardial infarction	487 (50.5)
Pharmacologic stress test	290 (30.1)
Left bundle branch block	89 (9.2)
Insufficient ECG quality	73 (7.6)
Non-specific intraventricular conduction abnormalities	24 (2.5)
Left posterior hemiblock	2 (0.2)

Exercise ECG

Significant stress-induced ST depression was present in 349 control patients (76%), 13 patients with LAHB (19%), and 17 with RBBB (44%). According to the results of SPECT imaging, exercise testing was truly positive in 60 controls (13%), in 8 patients with LAHB (12%), and in 2 patients with RBBB (5%). The test was false positive in 311 patients, ie in 289 controls (63%), in 7 patients with LAHB (10%), and in 15 patients with RBBB (38%). On the other hand, the exercise ECG was electrically false negative in 24 patients with abnormal SPECT studies, ie in 10 controls (2%), in 10 patients with LAHB (14%), and in 4 patients with RBBB (10%). Examples of false negative and true positive exercise ECGs are given in figures 1A and 1B respectively.

Diagnostic accuracy of exercise ECG

The sensitivity, specificity, and positive and negative predictive values based on the presence or absence of LAHB and RBBB on baseline ECG are given in table 3.

The sensitivity of the exercise ECG was lower in patients with LAHB and RBBB than in controls, and specificity was higher in patients with LAHB than in control patients and patients with

Table 2
Clinical characteristics.

	Control	LAHB	RBBB	p Value
Number of patients	459	69	39	
Age, years	55.2 ± 10.1	58.9 ± 8.9†	55.3 ± 10.1	0.02
Male gender	274 (49.9)	58 (84.1)	29 (74.4)	0.0002
Arterial hypertension	169 (36.8)	33 (47.8)	19 (48.7)	ns
Diabetes mellitus	17 (3.7)	3 (4.3)	2 (5.1)	ns
Typical chest pain	176 (38.3)	17 (24.69)	13 (33.3)	ns
Previously diagnosed CAD	102 (22.2)	32 (46.4)†	9 (23.1)	<0.0001
Coronary angiography	101 (22.0)	28 (40.6)	12 (30.8)	0.003
1-vessel disease	45 (44.6)	9 (32.1)	5 (41.7)	ns
2-vessel disease	27 (26.7)	11 (39.3)	4 (33.3)	ns
3-vessel disease	18 (17.8)	7 (25.0)	2 (16.7)	ns
Betablocker	135 (29.4)	23 (33.3)	12 (30.8)	ns
Ca-channel blockers	92 (20.0)	11 (15.9)	7 (17.9)	ns
ACE inhibitors	79 (17.2)	18 (26.1)	4 (10.3)	ns
Nitrates	73 (15.9)	22 (31.9)	4 (10.3)	0.002
LVEF, %	59.7 ± 5.0†	56.5 ± 8.2	57.0 ± 5.7	<0.0001
Heart rate at rest, bpm	76.6 ± 13.7	73.2 ± 12.6	75.9 ± 16.3	ns
Heart rate at peak, bpm	169.3 ± 9.3*	165.7 ± 9.8*	168.3 ± 9.6	0.01
Percent of target heart rate	102.8 ± 3.0	102.9 ± 2.8	102.3± 2.6	ns

Values are mean ± SD or numbers (%). LAHB, left anterior hemiblock; RBBB right bundle branch block; LVEF, left ventricular ejection fraction; bpm, beats per minute; ns, non-significant; † denotes significant difference compared to both of the other groups, * denotes significant differences between two marked groups.

RBBB. Figures 2 and 3 illustrate sensitivity and specificity according to increasing ST-segment depression cut-off values.

In an additional analysis the diagnostic accuracy of ischaemia-induced ST changes in patients with isolated LAHB (n = 43), LAHB and RBBB (n = 26), or in all patients with LAHB (n = 69), were compared (tab. 3 and fig. 4). The test's sensitivity was not significantly lower in the presence of bifascicular block than in the presence of isolated LAHB, whereas the test's specificity appeared to be lower in patients with bifascicular block when compared to patients with isolated LAHB.

QRS-configuration subgroup analysis in patients with LAHB

The patients with LAHB included 47 with rS configuration (r<S) and 22 with Rs configuration (R>s) in leads V4–V6. The sensitivity of the test was 20% in patients with rS (r<S), but 67% in patients with Rs (R>s) configuration.

Discussion

The principal results show that the diagnostic accuracy of ECG stress testing is decreased in patients with LAHB, in relation with a marked reduction in test sensitivity. Accordingly, the absence of ST-segment depression in patients with LAHB has a lower negative predictive value than in patients with normal baseline ECG. The reduction in test sensitivity appeared to be similar in patients with isolated LAHB compared with patients with RBBB or with bifascicular block (LAHB and RBBB). In contrast to its low sensitivity and negative predictive value, the test has excellent positive predictive value.

LAHB occurs when an impulse spreads first through the left posterior fascicle, causing a delay in activation of the anterior and lateral walls of the left ventricle. In patients with LAHB, the amplitude of positive QRS deflection in V4–V6 may be markedly decreased, as illustrated in our series: the positive vector in V5–6 (r wave) was lower than the negative vector (S wave) in 58% of the patients.

Stress-induced ST segment depression is caused largely by reduction of perfusion to the sub-endocardium, the zone most vulnerable to ischaemia, and is usually manifest during exercise ECG in leads V4–V6. In these leads R waves are dominant, ischaemia-induced variations of the ST

Table 3
Sensitivity, specificity, positive and negative predictive values of exercise-induced ST depression.

	Sensitivity	Specificity	PPV	NPV
Normal	86	26	17	92
RBBB	33	55	12	82
LAHB	38	87	46	82
LAHB subgroups				
Isolated LAHB	38	97	83	78
LAHB + RBBB	33	75	14	90

Values are percent. LAHB, left anterior hemiblock; RBBB right bundle branch block; PPV and NPV, positive and negative predictive values.

Figure 1

Panel A. False negative exercise ECG in a patient with LAHB and r<S pattern in left precordial leads. ECG leads V4–6 at maximal heart rate in a 52-year-old man with exercise angina, LAHB at baseline ECG. SPECT studies showed anterolateral ischaemia. Despite a double product (heart rate x systolic blood pressure) of 37,620 there is no significant ST depression and the stress test is negative. The coronary angiogram showed severe 3-vessel disease (70–90% proximal stenosis of the left anterior descending artery, 50–70% stenosis of the circumflexa, and a 50% stenosis of the right coronary artery) and severely impaired left ventricular function (ejection fraction 37%), and the patient underwent surgical revascularisation. Panel B. True positive exercise ECG in a patient with left anterior hemiblock and R>s in left precordial leads. ECG leads V4–6 at maximal heart rate in a 63-year-old man with a history of aortocoronary bypass surgery who presented with stable angina. On exercise ECG (double-product of 26,630), he developed typical chest pain. ST depression exceeds 1 mm in V4–V5, and the test is electrically positive. The coronary angiogram showed severe 3-vessel disease and occlusion of 2 of the three grafts. The patient underwent surgical revascularisation.

A

B

segment being discordant. While the depth of ST depression is chiefly determined by the severity of ischaemia and the extent of ischaemic area, it is also influenced by the amplitude of the R wave. Accordingly, it can be assumed that ST-segment response to ischaemia is decreased due to the small positive vectors in the lateral precordial leads which are typical of LAHB.

In agreement with this assumption, a subanalysis suggests that the sensitivity of the test may be at least partially preserved in patients with LAHB and larger positive vectors in the lateral precordial leads, defined by R>s in V5–V6.

In our study the specificity of ECG exercise stress testing in the control group was low compared to the majority of previous studies [9–11]. This may have been due to referral bias: on the one hand, patients with negative exercise stress testing may have been dismissed without further clinical investigations such as SPECT imaging, thus reducing the overall number of true and false negative results. This may explain the fact that the number of positive test results was considerably higher than the number of negative results. On the other hand, patients with acute coronary syndrome or very high pre-test probability for coronary artery disease were investigated by coronary angiography without previous exercise testing. However, since this patient selection procedure is recommended in most clinical guidelines, the resulting population investigated in our study can be considered typical of a cardiological clinical environment.

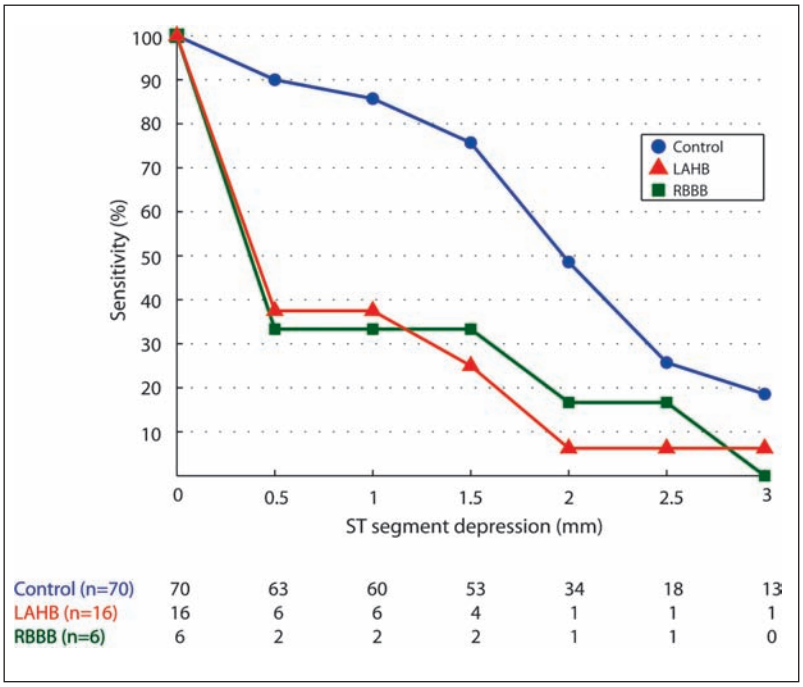

Figure 2

Sensitivity of exercise ECG to detect myocardial ischaemia according to different ST depression cut-off values in the three groups. LAHB, left anterior hemiblock, RBBB, right bundle branch block. The numbers of true positive results are indicated. See text for detailed explanation.

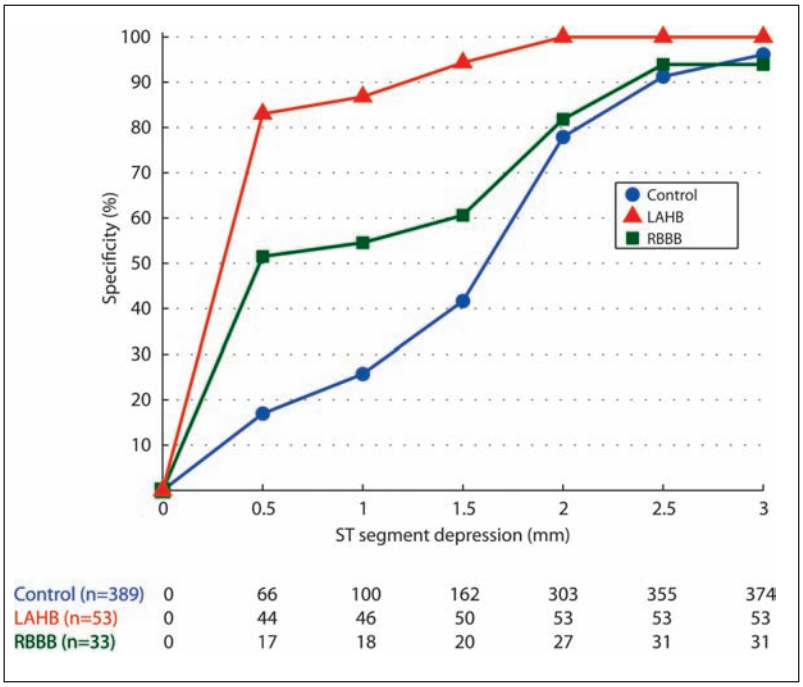

Figure 3

Specificity of exercise ECG for the detection of myocardial ischaemia according to different ST depression cut-off values in the three groups. LAHB, left anterior hemiblock, RBBB, right bundle branch block. The numbers of false positive results are indicated. See text for detailed explanation.

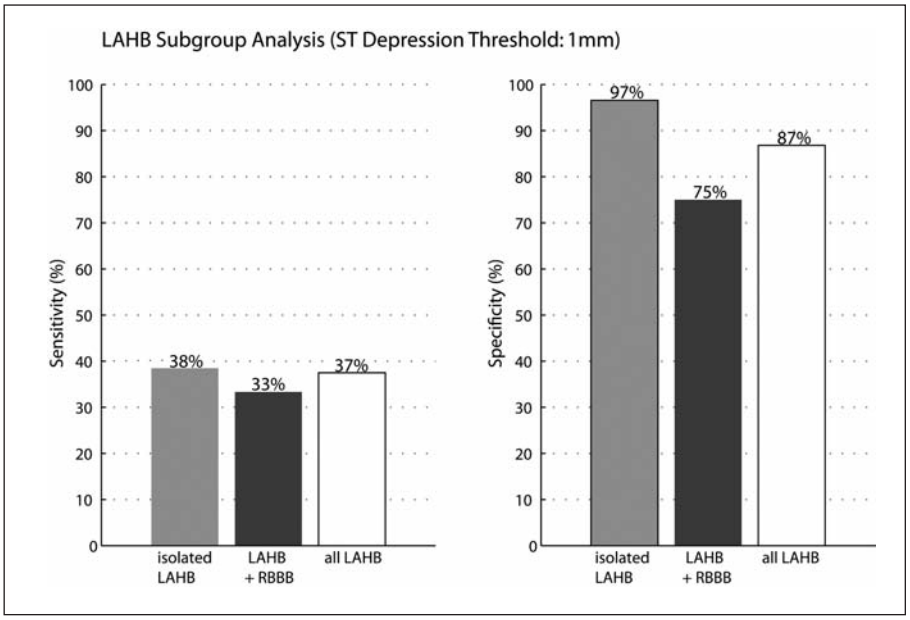

Figure 4

Box plots showing sensitivity and specificity values of exercise ECG in the subgroup analysis comparing patients with isolated left anterior hemiblock (LAHB), LAHB associated with right bundle branch block (RBBB), and isolated RBBB. See text for detailed explanation.

Limitations

We used SPECT imaging as reference for the presence or absence of ischaemia. This technique has known limitations in the evaluation of patients with left main stenoses and severe three-vessel disease, but diagnostic accuracy was reported to be excellent even in patients with RBBB and LAHB [12].

Clinical implications

Our findings have important clinical implications. In view of the low negative predictive value of stress induced ST-segment depression, other functional tests should be preferred to evaluate coronary perfusion in patients with LAHB. The sensitivity of the exercise ECG is particularly low in patients with an rS pattern in V5–6. However, in the small group of patients with LAHB and large positive vectors in lateral precordial leads (R>s in V5–6), sensitivity attains higher values than in patients with a very small positive vector in these leads. Finally, in the rather uncommon eventuality of exercise-induced ST depression in the setting of LAHB (with or without RBBB), the specificity of the finding as a marker of ischaemia is very high.

In conclusion, exercise ECG has a reduced sensitivity in detecting myocardial ischaemia in patients with LAHB, and other functional tests should be considered.

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References

1 Meyers DG, Bendon KA, Hankins JH, Stratbucker RA. The effect of baseline electrocardiographic abnormalities on the diagnostic accuracy of exercise-induced ST segment changes. Am Heart J. 1990;119:272–6.
2 Orzan F, Garcia E, Mathur VS, Hall RJ. Is the treadmill exercise test useful for evaluating coronary artery disease in patients with complete left bundle branch block? Am J Cardiol. 1978;42:36–40.
3 Whinnery JE, Froelicher VF Jr, Longo MR Jr, Triebwasser JH. The electrocardiographic response to maximal treadmill exercise of asymptomatic men with right bundle branch block. Chest. 1977;71:335–40.
4 Tanaka T, Friedman MJ, Okada RD, Buckels LJ, Marcus FI. Diagnostic value of exercise-induced S-T segment depression in patients with right bundle branch block. Am J Cardiol. 1978; 41:670–3.
5 Wangsnes KM, Gibbons RJ. Optimal interpretation of the supine exercise electrocardiogram in patients with right bundle branch block. Chest. 1990;98:1379–82.
6 Yen RS, Miranda C, Froelicher VF. Diagnostic and prognostic accuracy of the exercise electrocardiogram in patients with preexisting right bundle branch block. Am Heart J. 1994;127: 1521–5.
7 Cortigiani L, Bigi R, Rigo F, Landi P, Baldini U, Mariani PR, Picano E. Diagnostic value of exercise electrocardiography and dipyridamole stress echocardiography in hypertensive and normotensive chest pain patients with right bundle branch block. J Hypertens. 2003;21:2189–94.
8 Castellanos A Jr, Lemberg L. Diagnosis of isolated and combined block in the bundle branches and the divisions of the left branch. Circulation. 1971;43:971–6.
9 Gianrossi R, Detrano R, Mulvihill D, Lehmann K, Dubach P, Colombo A, McArthur D, Froelicher V. Exercise-induced ST depression in the diagnosis of coronary artery disease. A meta-analysis. Circulation. 1989;80:87–98.
10 Cardiovascular stress testing: a description of the various types of stress tests and indications for their use. Mayo Clinic Cardiovascular Working Group on Stress Testing. Mayo Clin Proc. 1996;71:43–52.
11 Tilkemeier PL, Katz AS, Parisi AF. The role of noninvasive testing in evaluating patients for coronary artery disease. Curr Opin Cardiol. 1996;11:409–17.
12 Paredes E, Candell-Riera J, Oller-Martinez G, de Leon G, Aguade-Bruix S, Castell-Conesa J. Myocardial perfusion SPECT in right bundle branch block and left anterior hemiblock. Rev Esp Cardiol. 2004;57:1117–20.

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