Does the routine use of lead V_4R increase prognostic yield in exercise electrocardiography?

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Abstract

We studied the potential benefits of using lead V_4R during routine exercise treadmill testing for patients undergoing district general hospital investigation for suspected coronary artery disease. Some 298 patients with known or suspected coronary artery disease, referred for exercise testing, had an electrocardiogram recorded with standard leads and had lead V_4 placed in the V_4R position. The exercise tests were interpreted using standard criteria and were reported as being negative, inconclusive, positive or adversely positive. The mean age of the patients was 57 years. Some 86 (29%) of the tests were positive: 12 of the 86 positive tests showed significant changes in lead V_4R (14%). Of the 86 positive tests, 25 were adversely positive (29%) and, of these, nine had a positive V_4R test (36%). Patients with V_4R positive tests compared to those with V_4R negative tests had significantly decreased exercise duration leads with ST changes and reduced workload. The finding of a positive V_4R test indicated a significantly greater chance of an adversely positive exercise test result ($p<0.001$), with nine of the 12 positive V_4R results (75%) being associated with adversely positive tests. There were no isolated positive V_4R tests.

Key words: exercise testing, lead V_4R, adverse prognosis, positive exercise test, coronary artery disease.

Introduction

In a significant proportion of patients, exercise testing proves an imperfect test for the detection or exclusion of coronary artery disease. The reliability, limitations and use of exercise electrocardiography have been carefully established over many years: the predictive accuracy of a positive test increases with increasing prevalence of the disease in the population.[1,2] A meta-analysis of 150 studies revealed that exercise-induced ST segment alterations identified coronary artery disease with a mean sensitivity of 68+/-16% and a mean specificity of 77+/-17%.[3] This is particularly evident in patients with isolated right coronary or left circumflex disease. McHenry *et al* showed that, in a studied population of patients with suspected or known coronary artery disease, 75% of negative tests were found to be in patients with disease limited to a single coronary artery.[4] In 92% of these patients the disease was limited to the right coronary or left circumflex artery.

By using a combination of right and left precordial leads the diagnostic accuracy of exercise testing for the detection of isolated right coronary artery disease can be enhanced, with sensitivity increasing from 50% to 75% in certain cases without affecting the specificity.[5-8]

We studied the potential benefits of using lead V_4R during routine exercise treadmill testing for patients undergoing district general hospital investigation for suspected coronary artery disease.

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Methods

All patients referred for exercise testing for ischaemic heart disease over a three-month period were included in the study. Excluded from the trial were patients who had left bundle branch block, those taking digitalis therapy, and those with significant hypertension >220/110 mmHg and significant left ventricular hypertrophy and strain on the resting electrocardiogram (ECG). The study included 298 patients with known or suspected coronary artery disease.

Exercise testing

All patients performed a symptom-limited exercise test on a standard Marquette Max 1 treadmill system, according to the Bruce protocol.

The exercise test was terminated at the patient's request if he had significant angina, dyspnoea, exhaustion or musculoskeletal pain. The test was also terminated if there was ST segment depression >3mm, ST segment elevation >2mm, a marked fall in the systolic blood pressure (>20 mmHg) and/or a fall in heart rate despite increasing cardiac workload. In addition, marked exercise hypertension (blood pressure >240/110 mmHg) and significant arrhythmias (including supraventricular arrhythmias, increasing frequency of ventricular ectopics, ventricular bigeminy, trigeminy or salvos) led to termination of the

test. If a patient reached 100% of the expected heart rate (ie. 220 minus age for a male patient, 210 minus age for a female patient) for longer than one minute, the test was terminated.

Each patient undergoing exercise testing had an electrocardiogram recorded with the standard leads and with lead V_4 placed in the V_4R position (the right mid-clavicular line at the fifth intercostal space).

Electrocardiograms and blood pressure were recorded with the patient at rest, both supine and erect. Then recordings were taken at the end of each stage during exercise and at each minute into the recovery phase until the patient's resting electrocardiogram, blood pressure and pulse rate returned to resting levels.

Outcome measures

Exercise-induced ischaemic changes in the standard leads or the right precordial lead were defined as horizontal or downsloping ST segment depression or ST elevation of at least 1 mm 80 ms after the J point compared with the baseline echocardiogram.

The exercise electrocardiogram was considered to be negative for inducible ischaemia when the heart rate reached at least 85% of the maximal predicted value in the absence of ischaemic ST segment changes. Exercise electrocardiograms without ST segment changes which were terminated when the heart rate was less then 85% of the predicted maximal rate were considered to be submaximal and inconclusive

Table 1 describes the criteria for adverse prognosis on exercise testing that we used in this study.

The exercise tests were interpreted using standard criteria and were reported as being negative, inconclusive, positive or adversely positive.

Results

There were 204 male and 94 female patients in this study. Their mean age was 56.6±0.65 years, range 27–79 years.

Eighty-six (29%) of the tests were positive (table 2).Of these, 12 (14%) showed significant changes in lead V_4R.

Twenty-five of the 86 positive tests were adversely positive and, of these, nine (36%) had a positive V_4R test.

Patients with V_4R positive tests had significantly decreased exercise duration, more leads with ST segment changes and reduced workload (table 3).

Conclusions

V_4R positive tests are uncommon, showing changes in this lead in only 12.5% of positive tests. There were no isolated positive V_4R tests in this study. A positive V_4R result was indicative of a high chance of having an adverse test (75%) and 36% of all adverse tests showed changes in this lead. Previous recognised adverse features are ST segment depression induced in the first two stages of the Bruce protocol or at a heart rate of less than 140 beats per minute.[1,9]

The population of patients referred to a district general hospital with no ready facilities for on-site coronary angiography may differ from those referred to a tertiary centre. Also, epidemiological studies suggest that the population of the North East of England is more likely to suffer more widespread and complicated coronary artery disease. This may account for the smaller number of patients with isolated changes in V_4R, suggesting isolated right coronary or circumflex disease, compared with the groups previously investigated.

In conclusion, our study suggests that the finding of a positive V_4R exercise test is a further adverse feature. This would imply that such patients are in a worse prognostic group, likely to have more widespread and significant underlying coronary disease.

Table 1. Adverse prognostic exercise tests

>3mm ST segment depression on exercise
Early onset (within 3 minutes) of ST segment depression
Persistence (>5 minutes) of ST segment depression during the recovery phase
Failure of systolic blood pressure to rise on exercise
Fall in systolic blood pressure during exercise
Serious ventricular arrhythmias at low heart rates (< 140 beats per minute)

Table 2. Positive exercise tests

	Positive V_4R	Total positive tests	Adversely positive V_4R	Total adversely positive
Male	9	58	8	17
Female	3	28	1	8

Table 3. Analysis of positive exercise tests

Measurements	V_4R positive	V_4R negative	Significance (p value)
Exercise duration (seconds)	320±39	426±19	0.03
Workloads (METS)	7.0±0.62	8.6±0.33	0.03
Leads with ST depression	5.0±0.43	3.32±0.17	0.02
Rise in systolic blood pressure (mmHg)	30.1±6.4	37.1±2.6	0.33
% maximum predicted heart rate achieved	84.6 ± 4.3	87.5 ± 1.8	0.54

Results are expressed as mean ± SEM

Key messages

- Exercise testing is an imperfect test for detecting or excluding coronary artery disease
- A positive V_4R test indicated a significantly greater chance of an adversely positive exercise test result
- There were no isolated positive V_4R tests
- Patients with positive V_4R tests are likely to have more widespread and significant coronary disease

References

1 Goldschlager N, Selzer A, Cohn K. Treadmill stress tests as indicators of presence and severity of coronary artery disease. *Ann Intern Med* 1976; **85**:277-86.

2. Bartel AG, Behar VS, Peter RH, Orgain ES, Kong Y. Graded exercise stress tests in angiographically documented coronary artery disease. *Circulation* 1974;**69**:348-56.
3. Gianrossi R, Detrano R, Mulvihill D *et al*. Exercise-induced ST depression in the diagnosis of coronary artery disease; a meta-analysis. *Circulation* 1989;**80**:87-98.
4. McHenry PL, Phillips JF, Knoebel SC. Correlation of computer-quantified treadmill exercise electrocardiogram with arteriographic location of coronary artery disease. *Am J Cardiol* 1972;**30**:747-52.
5. Michaelides AP, Psomadciki ZD, Dilaveris PE *et al*. Improved detection of coronary artery disease by exercise electrocardiography with the use of right precordial leads. *N Engl J Med* 1999;**340**(5):340-5.
6. Krueger DW, Lesnefsky EJ, Groves BM, Lindenfeld JL. Right ventricular ischaemia and proximal right coronary artery narrowing indicated by exercise ST-segment elevation in lead V1. *Am J Cardiol* 1989;**63**:107-9.
7. Braat SH, Kingma JH, Brugada P, Wellens HJJ. Value of lead V4R in exercise testing to predict proximal stenosis of the right coronary artery. *J Am Coll Cardiol* 1985;**5**:1308-11.
8. Chouhan L, Krone RJ, Keller A, Eisencramer G. Utility of lead V_4R in exercise testing for detection of coronary artery disease. *Am J Cardiol* 1989;**64**:938-9.
9. McNeer JF, Margolis JR, Lee KL *et al*. The role of the exercise test in the evaluation of patients for ischaemic heart disease. *Circulation* 1978; **57**:64-70.