Detecting asymptomatic coronary artery disease using routine exercise testing and exercise thallium scintigraphy in patients with atherosclerotic vascular disease

F. J. J. VAN DER WATT, C. J. C. NEL, P. J. JORDAAN, A. C. OTTO, A. M. TRAVERS

Summary

ECG-monitored exercise testing has been proposed as a relatively inexpensive and effective means of screening for asymptomatic coronary artery disease in patients presenting for peripheral vascular surgery. Despite the fact that exercise thallium scintigraphy is also dependent on the patient's ability to exercise, using this test in conjunction with ECG-monitored exercise testing may enhance sensitivity and specificity of non-invasive evaluation. Thirty-two patients were subjected to ECG-monitored exercise testing, exercise thallium scintigraphy and coronary angiography. The sensitivity of ECG-monitored exercise testing for detecting coronary artery disease was calculated at 81.8% and the specificity at 87.5%, while the figures for exercise thallium scintigraphy were 73.1% and 33.3% respectively. Using these two methods in combination yielded a predictive accuracy of 90.6%. The only advantage of exercise thallium scintigraphy over exercise ECG appears to be in patients in whom the latter test could not be interpreted or was non-diagnostic.

Patients and methods

Thirty-two patients admitted to the Department of Surgery, Universitas Hospital, Bloemfontein, with either atherosclerotic disease of the extremities (peripheral vascular disease (PVD)), carotid artery stenosis (CAS) or abdominal aortic aneurysm (AAA) were included in the study. Symptom-limited exercise testing was carried out using the Bruce protocol on a programmed Bürdick T500 treadmill. Patients unable to achieve at least 85% of maximum predicted heart rate (MPHR) and who did not develop angina, ischaemic ST changes, hypotension or complex arrhythmias were subsequently exercised using an adaptable Würzburg arm ergometer according to the protocol suggested by Williams et al. Continuous 12-lead ECG monitoring was used during the period of exercise, and resting ECGs were recorded in a supine and a standing position before and after completion of exercise. The test was terminated in the event of claudication, dyspnoea, fatigue, angina, ventricular arrhythmias, hypotension or marked ischaemia on ECG. All ECGs were interpreted by a cardiologist familiar with exercise testing but who did not have prior knowledge of the patient's clinical condition. Tests were taken as positive in the presence of horizontal or down-sloping ST-segment depression of 1 mm or more, a fall in systolic blood pressure of $\geq 10$ mmHg and exercise-induced angina or complex ventricular arrhythmias.

Thallium stress imaging was performed with arm ergometry in 12 patients and with treadmill exercise in 20 patients. Approximately 60 seconds before the termination of exercise, 2-3 mCi thallium-201 was administered through a peripheral line. Single photon emission computed tomography (SPECT) was then performed within 5 minutes, using a General Electric Starcam 400 ACT gamma camera. Images were photographed in 32 steps over 180° rotation. Redistribution images were photographed approximately 3 hours later. Pre-processing of the data was performed followed by back projection with a ramp filter. Orthogonal reconstructions of the vertical long axis, horizontal long axis and short axis of the heart were obtained. On these three images the anterior, lateral, inferior, septal and apical areas of the heart could be distinguished. The three sets of reconstructions were displayed on the computer screen and the five territories of the heart visually assessed by one or two experienced observers. A territory was classified as positive for CAD when a reduction in radioactivity existed on the stress images. A reversible defect was classified as an area where redistribution of the $^{201}$TI occurred.

Pre-operative cardiac evaluation of surgical patients has evolved greatly since a multifactorial risk index was first described by Goldman et al. The need to estimate operative risk prospectively is of particular importance in patients undergoing major vascular surgery, where the incidence of associated coronary artery disease (CAD) and related cardiac complications is alarmingly high.

While routine pre-operative coronary angiography has been suggested, non-invasive tests, such as exercise stress testing, gated blood pool scanning and dipyridamole-thallium scanning, have been emphasised as the first step in identifying high-risk patients. The ability of patients presenting for vascular surgery to participate in exercise studies is often hampered by severe claudication, ischaemic rest pain, ischaemic ulceration and previous limb amputation. An added problem is that certain drugs, such as digitalis, diuretics and $\beta$-blocking agents, may complicate interpretation of the test. Despite the fact that exercise thallium scanning is also dependent on the patient's ability to exercise, the addition of this method of examination to ECG-monitored stress testing may result in a greater sensitivity and specificity being achieved.

A study was undertaken to determine whether the addition of thallium imaging to conventional exercise stress testing holds any benefits in detecting associated asymptomatic but haemodynamically significant CAD in patients admitted to hospital for peripheral vascular surgery.
Coronary angiography was performed using the transcucaneous femoral Seldinger technique. Obstruction of more than 50% in at least one of the major coronary arteries was considered haemodynamically significant.

The sensitivity, specificity and predictive accuracy of exercise stress testing and exercise thallium scintigraphy were calculated by comparing the results with coronary angiography. Data were then analysed to simulate a stepwise clinical decision-making process. In this algorithm, clinical evaluation and resting ECG (definite angina, previous myocardial infarction or ischaemic changes on the resting ECG) were followed by treadmill stress testing, arm ergometry and, finally, exercise 201TI scintigraphy. A positive history or resting ECG were not regarded as an end-point for the purpose of the algorithm and all patients were routinely subjected to an exercise test. Exercise tests were considered negative if the patient reached 85% of MPHR and the ECG remained normal.

Results

The age range of the patients included in the study was 36 - 69 years (mean 59 years) and the group consisted of 28 men and 4 women. Four patients presented with CAS, 22 with PVD and 6 with AAA. After evaluating the clinical history and resting ECG, 18 patients (56.3%) had a previous myocardial infarction, angina or ischaemic ECG changes. The predictive accuracy of this evaluation was 68.8%. The results of 201TI-stress scanning (9 patients with reversible defects, 14 with fixed defects and 9 normal) and ECG are shown in Tables I and II. Two patients showed signs of left bundle branch block on resting ECG and were not included in the ECG part of the study. Fifteen patients had positive treadmill tests and 2 others managed to reach 85% of their MPHR with a normal stress test. Another 4 patients showed signs of myocardial ischaemia during arm ergometry, while 3 arm ergometry tests remained normal in spite of patients reaching 85% of their MPHR (Fig. 1). Fourteen treadmill tests were discontinued prematurely because of claudication (7 patients), fatigue (6) and asthma (1). The final decision-making algorithm had a predictive accuracy of 90.6% (Fig. 2).

Discussion

CAD commonly accompanies PVD and is the most common cause of early and late postoperative death after major vascular

![Table I. Summary of exercise tests performed](image)

<table>
<thead>
<tr>
<th>Tests performed</th>
<th>THR reached</th>
<th>Positive tests</th>
<th>+ test/THR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treadmill</td>
<td>23</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Arm ergometry</td>
<td>13</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>15</td>
<td>19</td>
</tr>
</tbody>
</table>

THR = 85% of maximum predicted heart rate reached.

Coronary angiographic findings are shown in Table III. Two of the patients classified as having normal coronary arteries had previous coronary angioplasties after myocardial infarctions and were expected to have corresponding fixed defects on 201TI-scintigraphy but a normal exercise ECG. Twelve of the 32 patients were referred for CABS before their PVD procedure, while 2 other patients were referred for CABS after PVD surgery.

![Table II. Accuracy of exercise testing and exercise 201TI scanning compared with coronary angiography to detect CAD in vascular patients](image)

<table>
<thead>
<tr>
<th>Exercise ECG</th>
<th>Exercise 201TI</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>THR*</td>
</tr>
<tr>
<td>All +</td>
<td>30</td>
</tr>
<tr>
<td>True +</td>
<td>19</td>
</tr>
<tr>
<td>False +</td>
<td>1</td>
</tr>
<tr>
<td>All -</td>
<td>18</td>
</tr>
<tr>
<td>True -</td>
<td>11</td>
</tr>
<tr>
<td>False -</td>
<td>7</td>
</tr>
<tr>
<td>CAD +</td>
<td>4</td>
</tr>
<tr>
<td>Sensitivity (%)</td>
<td>81,8</td>
</tr>
<tr>
<td>Specificity (%)</td>
<td>87,5</td>
</tr>
<tr>
<td>+ predicted value (%)</td>
<td>94,7</td>
</tr>
<tr>
<td>- predicted value (%)</td>
<td>63,6</td>
</tr>
<tr>
<td>Predicted accuracy (%)</td>
<td>83,3</td>
</tr>
</tbody>
</table>

*85% of maximum predicted heart rate reached.

**Fig. 1. ECG section of non-invasive algorithm.**

![Fig. 2. Non-invasive algorithm to detect CAD in vascular patients.](image)
The frequent inability of vascular patients to participate in treadmill exercise in eliciting exercise-induced ischaemic abnormalities (Van der Watt, Nel, Jordaan and Travers - unpublished data), the combination of these two methods had a predictive accuracy of 83.3% and a positive predictive value of 94.7% in the present study.

Asymptomatic CAD in patients under consideration for peripheral revascularisation (Table III), was one of the most important features of the present study. Bearing in mind the systemic nature of atherosclerosis, the admission to hospital of a patient for coronary angiography,4,14 followed, when indicated, by CABS or coronary angioplasty. It would, however, be more practical, safer and more cost-effective if an algorithm consisting of non-invasive tests could be used to identify patients with haemodynamically significant CAD who qualify for coronary angiography. Various algorithms have been suggested.4,15

ECG-monitored exercise testing has been proposed as a relatively inexpensive, easily applicable means of screening for asymptomatic CAD in patients presenting for major vascular surgery.2,3 Surgeons and anaesthetists have traditionally relied on the evaluation of risk factors, such as previous history of myocardial infarction, hypertension and angina, in an attempt to predict potential intra- and postoperative myocardial complications. Some objectivity was added to this approach by Cooperman et al.,10 Goldman et al.1 and others,11 who used multivariate analysis of risk factors to identify patients likely to have peri-operative myocardial complications. The accuracy of clinical history and resting ECGs in predicting the presence of significant CAD in the present study was high (68.8%) when compared with the study by Youngman et al.15 (36%). Different interpretation of resting ECGs may partially account for this.

Angiographic studies have shown that 22 - 30%4,13 of patients with a negative cardiac history and a normal resting ECG have significant CAD. Accordingly, some centres recommend routine pre-operative coronary angiography,4,14 followed, when indicated, by CABS or coronary angioplasty. It would, however, be more practical, safer and more cost-effective if an algorithm consisting of non-invasive tests could be used to identify patients with haemodynamically significant CAD who qualify for coronary angiography. Various algorithms have been suggested.4,15

Conclusions

The very high prevalence of significant but asymptomatic CAD in patients under consideration for peripheral revascularisation (Table III), was one of the most important features of the present study. Bearing in mind the systemic nature of atherosclerosis, the admission to hospital of a patient for vascular surgery offers the ideal opportunity to diagnose associated CAD. The only value of exercise 201TI scanning appears to be in patients with non-diagnostic stress tests (< 85% of MPHR) and stress tests that cannot be interpreted. The proposed non-invasive algorithm proved to be a very accurate means of selecting patients for pre-operative coronary angiography.

This study was supported by the South African Medical Research Council.

REFERENCES

Diabetes mellitus, pulmonary tuberculosis and chronic calcific pancreatitis revisited

W. F. MOLLENTZE, D. F. PANSEGROUW, A. F. STEYN

Summary

The prevalence of chronic calcific pancreatitis (CCP) was determined in 25 successive patients with both diabetes mellitus and newly diagnosed pulmonary tuberculosis. Twenty patients (80%) were alcoholics and all were black. Of these, 9 (45%) had CCP. In only 3 of these 9 patients was the pathology compatible with the condition diagnosed. Clinical steatorrhoea was absent in the patients with CCP. Pulmonary tuberculosis was extensive with major involvement of three or more lung zones in 36% of patients. Mainly basal involvement of the lungs was present in 8% of patients.

The risk of developing pulmonary tuberculosis is increased by chronic disabling diseases, such as diabetes and alcoholism. Defective chemotaxis of polymorphonuclear leucocytes from patients with diabetes mellitus has been reported. Impaired bactericidal function of granulocytes in patients with poorly controlled diabetes has also been demonstrated. Ethyl alcohol also depresses leucocyte migration to inflamed areas, which may contribute to the poor resistance of alcoholics to infection.

The incidence of pulmonary tuberculosis in a series of 3106 diabetics was 8.1%. In a previous study the prevalence of diabetes among patients with pulmonary tuberculosis admitted to an isolation department was found to be 2.1%. Thirty per cent of patients with chronic calcific pancreatitis (CCP) have or have had tuberculosis at some stage of their disease or during follow-up. The reported incidence of overt diabetes in patients with non-calcific pancreatitis was 30% as compared to 70% in patients with calcific pancreatitis.

A study was undertaken in order to establish the prevalence of CCP in patients with both diabetes and newly diagnosed pulmonary tuberculosis admitted to our local teaching hospitals over a 22-month period.

Patients and methods

Pulmonary tuberculosis was diagnosed on clinical, radiographic and sputum findings. Diabetes was diagnosed in non-established cases according to WHO criteria. A diagnosis of CCP was made after straight radiography of the abdomen. A detailed history of alcohol consumption, smoking, abdominal pain, steatorrhoea and a family history of diabetes was obtained.

Straight radiography of the abdomen was also performed in patients with diabetes mellitus and newly diagnosed pulmonary tuberculosis admitted to our local teaching hospitals over a 22-month period.

Results

During the study period 25 patients with diabetes and pulmonary tuberculosis were found. Table I summarises some of the data from this group of patients. Twenty of the 25 patients were heavy alcohol consumers and all 20 were black. They had used alcohol daily or binged over weekends for periods of 5-20 years. Nine of these 20 patients had radiographic evidence of CCP. A history consistent with acute intermittent pancreatitis was obtained in only 4 patients and of these only 3 had radiographic evidence of CCP. No history compatible with malabsorption or clinical steatorrhoea could be obtained from any of the patients. No patients in the control group had radiographic evidence of CCP. Nine patients (36%) from the control group admitted to past heavy alcohol consumption.

Department of Internal Medicine, University of the Orange Free State, Bloemfontein, OFS

W. F. MOLLENTZE, M.MED.(INT.), F.C.P. (S.A.)
D. F. PANSEGROUW, D.MED. SC., M.B. CHB.
A. F. STEYN, M.MED.(INT.)

Accepted 27 Feb 1990.