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Electrocardiographic criteria for detecting coronary artery disease in hypertensive patients with ST-segment changes during exercise testing

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Abstract

Purpose: It is well known that patients with arterial hypertension frequently present with ischemic electrocardiographic changes during exercise testing without actually having coronary artery disease (CAD). The purpose of this study was to establish additional electrocardiographic criteria during exercise testing for detecting CAD in hypertensive patients with ischemic ST-segment response.

Methods: Three hundred eighty-two consecutive hypertensive patients (224 males, 58 ± 8 years) who presented with ischemic electrocardiographic changes during exercise testing and agreed to undergo coronary arteriography were included in the study.

Results: From 382 hypertensive patients undergoing coronary angiography, only 76 (20%) had significant coronary stenosis, whereas 306 (80%) had normal coronary arteries. From 382 patients, 287 (75%) (group A) presented with ST-segment depression during exercise in leads II-III-aVF-V_6, 271 (94%) of which had normal arteries at the angiography. The remaining 95 patients (25%) (group B) of the studied patients presented with ST-segment depression in II-III-aVF and/or V_4 through V_6, 60 (63%) of which had CAD. Furthermore, 251 patients of group A presented with ST-segment depression during the fourth to sixth minute of the recovery period in V_4 through V_6, 247 (98%) of which had normal arteries. Another 28 patients from group B presented with ST-segment depression during the fourth to eighth minute of the recovery period in V_4 through V_6, 22 (79%) of which had significant coronary artery stenosis.

Conclusions: Hypertensive patients who present with ST-segment depression during exercise in leads II-III-aVF and/or V_4 through V_6 and with a prolonged duration of this depression at the recovery phase (fourth to eighth minute) are more likely to have CAD. Absence of ST-segment depression in V_4 and V_5 at the end of exercise or during the seventh and eighth minute of recovery favors a false-positive result.

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Introduction

It is well known that patients with arterial hypertension frequently present with ischemic electrocardiographic changes during exercise testing (ET), without actually having coronary artery disease (CAD).[1-3]

Besides, there are many hypertensive patients presenting with ST-segment changes during ET, while ultrasound imaging of the heart do not reveal significant ventricular hypertrophy.[4,5] These patients can also exhibit chest pain with no CAD, deriving from microvascular disease with structural abnormalities and endothelial dysfunction causing impaired coronary reserve.[6] In fact, these anatomic and functional changes in the microcirculation of the heart are commonly present before the presentation of ventricular hypertrophy. Systemic endothelial status can also be

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impaired in these patients with functional (impaired endothelium-mediated relaxation) and structural (perivascular fibrosis of the coronary microcirculation) alternations.[7,8]

Finally, neurohormonal factors, such as catecholamines, endothelin, and rennin-angiotensin system, may also impair coronary flow reserve in hypertensive patients.[9]

These alternations in the microcirculation of the heart can consequently produce ST-segment changes during exercise, in spite of the negative angiographic findings from the epicardial coronary arteries of these patients. These electrocardiographic (ECG) changes during exercise may be the earliest sign of myocardial ischemia, preceding even the wall motion abnormality which, according to the "ischemic cascade," is one of the earliest signs of ischemia, following the perfusion abnormalities.[10]

The presence of these ST-segment changes during ET reduces the specificity and positive prognostic value of the ET and is responsible for a considerable amount of false diagnoses of CAD.[11]

Because the diagnosis of CAD with ET based on the standard ST-segment depression criteria is uncertain, the establishment of accessional electrocardiographic criteria during exercise for the discrimination of exercise-induced ST-segment changes resulting from clinically important heart ischemia from those deriving from decreased coronary flow reserve as a consequence of hypertension would be of great value. We examined whether the magnitude of ST-segment depression during exercise in leads II-III-aVF and/or V_4 through V_6 as well as the duration of this depression at the recovery phase have the ability to identify CAD in hypertensive patients.

Methods

Study population

From 2004 to 2006, 382 consecutive hypertensive patients (224 males, 58 ± 8 years) who presented with ischemic electrocardiographic changes during ET and agreed to undergo coronary angiography were included in the study. During the recruitment period, a total of 1053 hypertensive patients were examined. From them, 427 (41%) presented with ischemic electrocardiographic changes during ET in our laboratory and 382 (89%) accepted to participate in our study.

The diagnosis of arterial hypertension was based on at least 2 blood pressure measurements per visit and at least 2 to 3 visits. Blood pressures were measured by the physician or the nurse in the office or in the clinic (office or clinic blood pressure), by the patient or a relative at home, or automatically over 24 hours.

Blood pressure thresholds (millimeters of mercury) for definition of hypertension with different types of measurement according to the European Society of Hypertension recommendations [12] are shown in Table 1.

When measuring blood pressure, care was taken to:

- Allow the patients to sit for several minutes in a quiet room before beginning blood pressure measurements.
- Take at least 2 measurements spaced by 1 to 2 minutes, and additional measurements if the first 2 are quite different.
- Use a standard bladder (12-13 cm long and 35 cm wide) but have a larger and a smaller bladder available for fat and thin arms, respectively.
- Have the cuff at the heart level, whatever the position of the patient.
- Use phase I and V (disappearance) Korotkoff sounds to identify systolic and diastolic blood pressure, respectively.
- Measure blood pressure in both arms at first visit to detect possible differences due to peripheral vascular disease. In this instance, take the higher value as the reference one.

Table 1
Blood pressure thresholds (millimeters of mercury) for definition of hypertension with different types of measurement

	SBP	DBP
Office or clinic	140	90
24-h	125-130	80
Day	130-135	85
Night	120	70
Home	130-135	85

SBP, systolic blood pressure; DBP, diastolic blood pressure.

The definition of ischemic electrocardiographic response during ET was based on the standard ST-segment deviation criteria (see "Treadmill ET" section).[3]

Patients with known history of CAD, left or right bundle-branch block, preexcitation syndromes, and those who were receiving digitalis or were unable to walk on treadmill were excluded.

All medications were discontinued for at least 5 half-lives before the ET.

The study was approved by our hospital's ethics committee, and written informed consent was obtained from all participants.

Treadmill ET

All patients performed exercises on a Marquette case system (G-Medical System, Milwaukee, WI), according to the multistage Bruce protocol.

Each patient had an ECG recorded with the standard 12 chest leads. The ECG was recorded continuously during exercise and for up to the 10th minute of the recovery period. Blood pressure was measured every minute, during exercise, and during the recovery period, with a sphygmomanometer.

Exercise was terminated in the presence of severe angina, fatigue, dyspnea, or severe arrhythmias. In the absence of symptoms, the test was terminated at the occurrence of ≥2 mm ST-segment depression or ≥1 mm ST-segment elevation, an exaggerated blood pressure response (≥250/115 mm Hg), or a decrease in systolic blood pressure ≥10 mm Hg.[3]

An ischemic ST-segment response during exercise and recovery was defined as additional horizontal or downsloping

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