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CASE REPORT

# ECG's AVR ST elevation Analysis by Perfusion Scintilography in the Context of Myocardial Ischemia

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## Introduction

The presence of ST-segment elevation in two or more contiguous leads indicates a current subepicardial lesion that often requires early intervention, either by angioplasty or thrombolytic therapy.[1,2] ST elevation, only in aVR, may also indicate the presence of an acute infarction.[3] This finding was first made by Wellens et al.[4] However, this is not always true,[5] and physicians should be aware of the details surrounding changes in Right Vector amplification (aVR).[6]

The medical literature has a wide range of articles reporting on the association between ST elevation in aVR during exercise testing and left main coronary artery injury.[7-9] However, this concept began at a time when fewer imaging tests and catheterizations were performed. Altered stress tests are a common indication of myocardial scintigraphy, which is why the Nuclear Medicine laboratory is the perfect place to perform this type of analysis. There is now evidence that aVR elevation in this context may not indicate coronary lesions and may be present, for example, in patients with aortic stenosis, hypertrophy and hypoxia..[10-12] Since these are stress tests, it is important to analyze the heart rate in which the aVR elevation occurs as well as the pattern of the other leads.[13]

When the heart rate increases, whether during a stress test or in other stressful situations, ST depression most often occurs first in the inferior wall, the site of greatest sensitivity to changes in the exercise test.[14] After, it is common to observe that ST depression progresses to the lateral wall, finally leading to aVR elevation. It should be noted that the ST depression does not locate the coronary artery with the lesion, only the elevation.[15] At the end of the test, with the decrease in heart rate, the aVR elevation tends to disappear; proportionally to the depression in the other derivations, as if in a mirror. In these cases, there is a chance that the aVR elevation does not mean left main coronary artery injury or three-vessel injury, meaning only a rightward reflection (aVR = Right Vector amplification) of the magnitude of the precordial changes on the left (inferiority) of the stress test. Cardiologists who are accustomed to working with ergometry come across changes in the ST segment in their daily work, nearly always starting in the inferior wall, progressing proportionally to the other leads, often culminating in an aVR elevation.

However, when the aVR elevation occurs in association with V1 alterations, the chance of finding coronary artery disease is greater.[16] Sensitivity increases even more if the alteration occurs in the presence of a low heart rate (far from submaximal) and chest pain, reinforcing the character of acute coronary syndrome and not merely a positive exercise test.

Altered coronary angiography and aVR elevation in treadmill tests gives the impression that this finding is specific, when in fact it is not. In a 2019 study, cases of aVR elevation were analyzed in the emergency room and only 10% had some type of thrombotic coronary occlusion.[17] Due to the observation that aVR elevation lead is relatively common in false-positive exercise tests routinely seen in myocardial scintigraphy, but which end up being highly valued in exams with ischemia, a review

## Keywords

Exercise Test; Electrocardiography; Radionuclide Imaging; Myocardial Ischemia.

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was proposed, through the discussion of 3 cases, based on the clinic, on the stress electrocardiogram (ECG), and myocardial perfusion images, from scintigraphy.

## Description

**Case 1:** 52-year-old hypertensive and asymptomatic male patient. Previous ergometry conducted one year ago was positive, investigated with coronary angiotomography with no lesions and with a calcium score of equal to zero. Myocardial perfusion scintigraphy with physical stress (ergometry) was requested for a preoperative evaluation of noncardiac surgery (Figure 1a).

Note the presence of ST depression in the inferior wall (Figure 1b), a site of great sensitivity to alterations in the ergometric test.[14] After, the ST depression evolves to the lateral wall (Figure 1c) when the aVR elevation occurs (Figure 1c).

The ECGs show that aVR elevation gradually disappears as the inferior wall (DII, DIII, and aVF) decreases, proportionally, as if in a mirror (Figure 1d).

This patient reported no chest pain during the test, and 99mTc-MIBI was injected at peak exertion (11 minutes).

Despite the electrocardiographic changes, the patient performed 11 METS, with no chest pain. The ST segment changes occurred with a high load and regressed rapidly during recovery. This information, despite the elevation in aVR, suggests the probability of a false positive, which, according to the exam, may suggest myocardial ischemia.[18]

The scintigraphy image shows normal perfusion at rest and after physical stress (Figure 1e).

The patient's resting and stress scintigraphy showing normal perfusion (which suggests ischemia) and no transient dilation of the left ventricular cavity or drop in the ejection fraction induced by stress. Since this patient had already presented an altered ergometry from a year ago, investigated using coronary angiotomography and showing no lesions, it was not necessary to repeat the anatomical exam.

**Case 2:** Hypertensive, asymptomatic, male patient with dyslipidemia and a history of myocardial revascularization, who had undergone surgery five years prior and had a history of infarction six years ago. Myocardial perfusion scintigraphy was requested to assess physical activity (Figure 2a).

The analysis of the physical stress ECG shows, in the second minute of recovery, an increase in ST depression

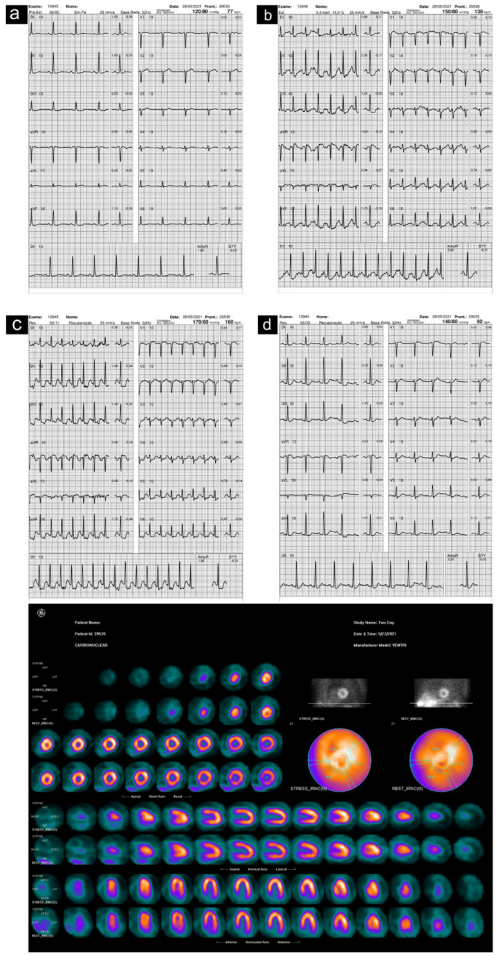


**Figure 1 – Case 1: ECG and myocardial perfusion scintigraphy during physical stress and at rest with 99mTc-MIBI. a) ECG at rest; b) ECG at peak effort; c) ECG during immediate recovery; and d) Last recovery.**

with a consequent increase in aVR elevation (Figure 2b). The alteration in the ST segment in V1 (Figure 2c and 2b) also reinforces an alteration suggestive of ischemia (Figure 2d).[8]

In Figure 2e, an area of infarction/fibrosis can be seen in the septal wall (bottom line), which could explain the elevation in V1 (Figure 2c). In addition, an image, suggestive of ischemia in the lateral and inferior walls (area of the right and circumflex coronary arteries), was observed. In this example, we have a critically ill patient with ischemia in more than one topography.

After receiving the results of the myocardial perfusion scintigraphy, a coronary angiography was requested, which showed a mammary artery to the patent anterior descending coronary artery; a severe lesion in the

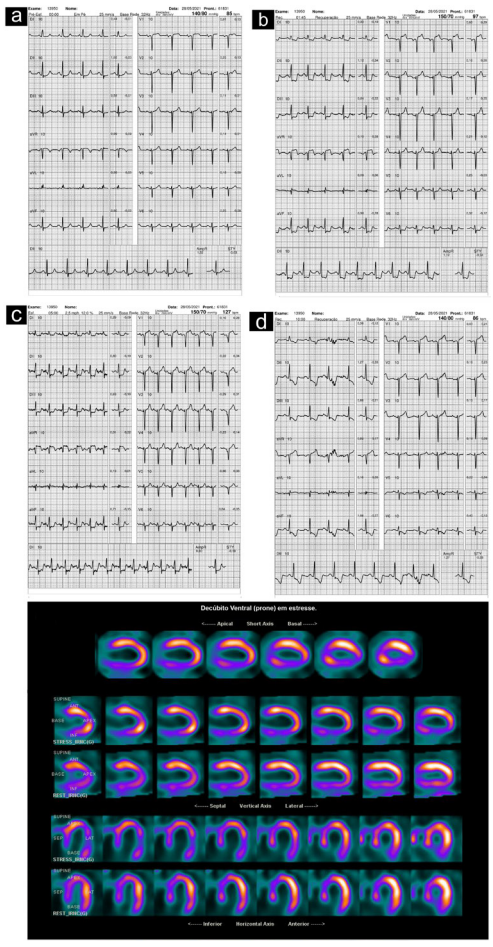


**Figure 2 – Case 2: ECG and myocardial perfusion scintigraphy under physical stress and at rest with 99mTc-MIBI. a) Resting ECG; b) ECG after 2 minutes of recovery; c) ECG after 5 minutes in the Bruce protocol; and d) ECG after 10 minutes of recovery.**

occluded saphenous vein graft; in addition to severe lesions in the native bed and in the saphenous bridge to the right coronary artery.

Two positive tests were then observed in asymptomatic patients.

Although there was aVR elevation in both cases, the second represents a greater probability of ischemia according to the perfusion scintigraphy exam, in the stress phase, for the following reasons:

1) The second patient began to change the ECG at low load (3 minutes), even without reaching the submaximal heart rate.

2) The electrocardiographic changes not only persisted during recovery, but were also accentuated in case 2. Cases of false positive tests generally show rapid improvement at the beginning of recovery.

3) In case 1, the ST segment changes regressed as soon as the treadmill stopped, even though the patient walked more than twice as much as the patient in case 2 (11 minutes).

**Case 3:** 70-year-old, hypertensive, diabetic male patient, who reported episodes of chest pain unrelated to exertion. A myocardial perfusion scintigraphy with physical exertion was requested to evaluate the symptoms.

Figure 3a shows the ECG at rest. In Figure 3b, after 6 minutes of exertion on the treadmill, ST-segment depression was noted in the inferior wall, as well as ST-segment elevation in aVR and V1 (Figure 3c). In Figure 3d, an increase in electrocardiographic changes is evident, even with a lower heart rate (8 minutes of recovery); the ST-segment elevation and aVR appear to progress proportionally to the depression in the other leads.

Figure 3e shows the myocardial perfusion of case 3, showing ischemia in the region of the anterior descending coronary artery. After this change, a coronary angiography was requested, which showed a lesion in the left anterior descending coronary artery. The patient was referred for angioplasty.

In general, when heart rate and blood pressure return to baseline, the ST segment returns to normal and the test can be ended.[19] Cases in which changes intensify during late recovery (Figure 3d) are considered more serious.[20] Therefore, when analyzing an exercise test, the moment at which the ECG changes is as important as, if not more important than, the type of change. This assessment helps to differentiate true cases from false positives.

In case 2, extensive ischemia was observed, predominantly in the region of the right and circumflex coronary arteries. In case 3, ischemia was observed in the region of the anterior descending coronary artery. This emphasizes that the exercise test does not locate the lesions, but rather indicates the degree of severity.

## Conclusions

Through retrospective analysis of aVR elevation on the ECG in exercise tests, it can be presumed that this alteration would be a determining factor for severe left main disease. However, aVR elevation appears to be a marker of the intensity of the test modification and, in many situations, severity is synonymous with significant left main disease of multivessel disease but this does

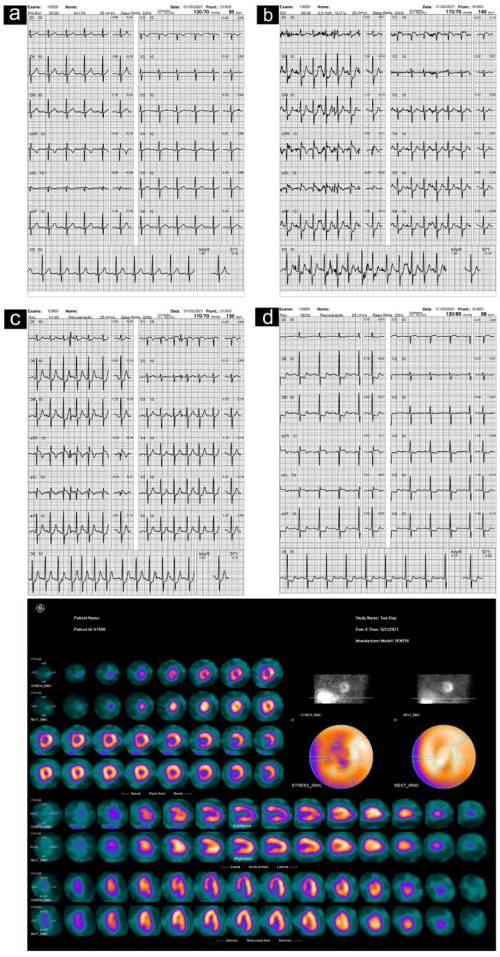


**Figure 3 – Case 3: ECG and myocardial perfusion scintigraphy during physical stress and at rest with 99mTc-MIBI. a) ECG at rest; b) ECG at 6 minutes (peak effort); c) ECG in the first minute of recovery; d) ECG in the 8th minute of recovery.**

not constitute a constant. As demonstrated in the three reported cases, some patients show provocative exercise tests with ST elevation in aVR, which can be interpreted in other ways. This fact could explain the result of the present study, which showed only 10% of thrombotic coronary occlusions in patients who sought emergency care with such an electrocardiographic alteration.[17] Therefore, when faced with this finding, it is essential to analyze the patient's heart rate, since the elevation often regresses when the heartbeats return to their baseline state. It is also important to observe the depression of the other leads, given that, in cases of acute coronary syndrome, it is usually greater in V4 and not in the inferior wall as occurs in stress tests.[20]

## Author Contributions

Conception and design of the research, writing of the manuscript and critical revision of the manuscript for intellectual content: Gomes MB, Fuchs FC; acquisition of data and statistical analysis: Gomes MB, Bombana CF; analysis and interpretation of the data: Gomes MB, Bombana CF, Fuchs FC.

### Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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### Study Association

This article is part of the thesis of master submitted by Miriana Basso Gomes, from PPG em Caridologia e Ciências Cardiovasculares da Universidade Federal do Rio Grande do Sul.

### Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of the IC/FUC under the protocol number 5.958.491. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

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