The Importance of the 15-lead Versus 12-lead ECG Recordings in the Diagnosis and Treatment of Right Ventricle and Left Ventricle Posterior and Lateral Wall Acute Myocardial Infarctions

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1. INTRODUCTION
The 12-lead ECG is the proper diagnostic method to establish the diagnosis of acute myocardial infarction (AMI), particularly in the early phase. However, the sensitivity of a single 12-lead ECG for the diagnosis of AMI is relatively weak (1). It has been advocated that the initial 12-lead ECG of patients proved to suffer from AMI, shows ST segment elevation in less than 50%, while in other cases it might show only minor ischemic changes, such as ST segment depression and T wave inversion (1). One has to keep in mind that ST depression in leads V1-V3 should raise strong suspicion of posterior wall infarction (2).

Moreover, in up to 30% of patients with acute coronary syndrome (ACS), the initial 12-lead ECG may be normal or showing non-specific abnormalities only (3). Nonetheless, a diagnostic initial ECG in a patient with AMI will allow the physician to promptly start the appropriate therapy, mainly reperfusion. It has repeatedly been demonstrated that recording additional leads on initial ECG may improve its sensitivity and the prognosis of selected cases (4, 5). Moreover, additional lead ECGs may reveal more accurately the extent of the myocardial injury (6). It is known that posterior or postero-lateral AMI might not be manifested with ST elevation on the classic 12-lead ECG (7). If this were the case, especially in the Emergency Department, then these patients could be offered specific reperfusion therapy, either thrombolysis or percutaneous coronary intervention (8). Therefore, the recording of posterior leads (V7, V8, V9) seems to be valuable and practical (9). Surprisingly, less than 40% of physicians request
the posterior leads on the initial ECG of patients hospitalized for ACS (10).

2. AIM

The aim of the study was to assess the usefulness of the 15-lead ECG (12 classic plus posterior leads V7, V8, V9) in the management of chest pain patients, with special focus on those whose 12-lead ECG was not diagnostic of AMI.

3. METHODS

We enrolled 186 consecutive patients (127 men, 59 women, mean age 69.7±13.8 years) who were admitted to the Coronary Care Unit (CCU) with the working diagnosis of ACS. The initial ECG recorded the 12 classic leads, and subsequently, the 3 additional posterior leads (V7: on the posterior axillary line, V8: on the posterior scapular line, V9: on the left border of the spine). Demographic and clinical data, including ECG alterations (ST elevation, ST depression, T wave inversion, Q waves and appearance of new bundle branch block) and selected treatment strategy, were studied. ST elevation on the posterior leads V7, V8, V9 was considered when it was ≥0.5 mm. The supplemental impact of the 15-lead ECG on the diagnosis and management of AMI was, overall, evaluated.

Patients were divided into two groups according to whether the initial 12-lead ECG could establish the STEMI diagnosis—Group A (158 patients, 127 men—59 women, mean age 66.7±13.8 years (Figure 1) or the additional posterior leads were required—Group B (28 patients, 20 men—8 women, mean age 68.9±18.8 years (Figures 2 and 3).

Statistical analysis

The Kolmogorov-Smirnov test (sample >50 patients) was applied to evaluate the normality of distribution of quantitative variables. Continuous variables (quantitative) were recorded with the mean±SD values and the categorical variables (qualitative) as a percentage (%). The t-test (Student test) was used to compare the continuous variables and the x²-test or Fischer test to compare the categorical variables. Forward stepwise multiple regression model, a model of multivariate regression analysis, was used to determine the factors associated with the final diagnosis of AMI (independent variable). Probability p < 0.05 (2-way) was considered statistically significant. The study protocol was approved by the Scientific Council of the Hospital (Number 16/2014). The statistical analysis was made using the SPSS.19 for Windows statistical package.

4. RESULTS

Table 1 shows the demographic and clinical data of the patients of the two groups. No significant differences were observed in gender, age, AMI diagnosis between the two groups. The 12-lead ECGs of Group B patients were not diagnostic of STEMI. Nevertheless, in 17 patients (60.7%), the ECG alterations would raise suspicion of isolated posterior infarction entailing the recording of the additional posterior leads (Figure 2). Notably, there was no such indicative ECG abnormality in the 12-lead ECGs of the remaining 11 patients (39.3%), who would fail the STEMI diagnosis and would not be offered reperfusion therapy if the posterior leads were not recorded (Figure 3). Multivariate analysis revealed that the 15-lead ECG was the sole factor significantly associated with achieving the STEMI diagnosis (OR=2.43–p=0.04, Table 2). On the whole, the 15-lead ECG was diagnostic of STEMI in more patients than the classic 12-lead
Figure 3. 15-lead ECG of a patient from group B: there were no ECG abnormalities on the classic 12 leads to indicate posterior AMI, which was confirmed when the additional leads were recorded (ST elevation on posterior leads V7, V8, V9).
shown in our study. Patients with inferior-posterior AMI
The true posterior AMI is a rare entity, as it has been
6, 13), often in conjunction with inferior or lateral ones.
6, 15). It accounts for 15-21% of all AMI (4, 5,
insults the left ventricular wall by occlusion of the right
diagnosis while determining its actual extent.
fore, the use of the 15-lead ECG may confirm the STEMI
the right V4 (RV4) that examine the right ventricle. There -
commonest additional leads are the posterior leads (V7,
the posterior and right ventricular involvement in AMI,
recording of the standard 12-lead ECG may subdiagnose
the prognosis of AMI patients (6, 13, 14). Of note, the sole
with the use of additional leads improving, as a result,
would warrant the recording of additional leads (12).
the classic 12-lead ECG (ST elevation or depression) that
posterior MI could be detected only with the additional
posterior MI and is superior to the findings in the anterior
is primary PCI. However, 60-70% of patients initially ar -
posterior-lateral AMIs, facilitating the decision for
is not defined and has been reported in studies ranging
is the circumflex artery (15). There are limited and
conflicting data on their utility in clinical practice.
Zalensky et al. (18) concluded that the application of
posterior leads to AMI detection has a sensitivity of 60%,
pecificity of 89%, a positive predictive value of 91% and
negative predictive value of 55%. In many cases, however,
the analyses are affected by the definition of pathological
ST elevation (≥0.5 mm). In our study pathognomonic ST elevation was defined
as ≥0.5 mm.
R waves in the anterior leads are simply the electrical
equivalents of the recorded Q waves in the posterior leads
(13, 17). Posterior leads illustrate ST elevations in posterior-
or lateral MI and a coronary vessel obstruction, predom-
antly the circumflex artery (15). There are limited and
specificity of 92%, a negative predictive value of 99% and
positive predictive value of 33% (21). A significant ST
depression on posterior leads in posterior infarctions will be
manifested as ST depression on the anterior V1-V3 leads.
The ischaemic criteria, in the same way, are the hori-
zontal ST depression, the tall R waves and the prominent
upright T waves on leads V1-V3 (7, 17). The prominent
R waves in the anterior leads are simply the electrical
equivalents of the recorded Q waves in the posterior leads
(13, 17). Posterior leads illustrate ST elevations in posterior-
or lateral MI and a coronary vessel obstruction, predom-
ine at non-PCI capable hospitals and therefore, throm-
bolysis should be administered (11).
It has previously been reported that approximately 11%
of patients (15% in our study) with ST elevation in the pos-
terior leads do not exhibit indicative abnormalities on
the classic 12-lead ECG (ST elevation or depression) that
would warrant the recording of additional leads (12).
The ECG sensitivity of STEMI diagnosis is increased
with the use of additional leads improving, as a result,
the prognosis of AMI patients (6, 13, 14). Of note, the sole
recording of the standard 12-lead ECG may subdiagnose
the posterior and right ventricular involvement in AMI,
as these leads do not directly reflect those segments. The
commonest additional leads are the posterior leads (V7,
V8 and V9) that view the posterior and lateral walls, and
the right V4 (RV4) that examine the right ventricle. There-
fore, the use of the 15-lead ECG may confirm the STEMI
diagnosis while determining its actual extent.
The term “posterior infarction” identifies an AMI that
insults the left ventricular wall by occlusion of the right
coronary artery–posterior descending branch or the cir-
cumflex artery (15). It accounts for 15-21% of all AMI (4, 5,
6, 13), often in conjunction with inferior or lateral ones.
The true posterior AMI is a rare entity, as it has been
shown in our study. Patients with inferior-posterior AMI
suffer from more severe AMI with lower left ventricular
posterior AMI
group B
Total
n=28
n=186
p
Age years
65.8±15.7
66.8±13.5
55.9±14.1
0.3
Male Gender n (%)
107 (67.7)
20 (79.4)
127 (68.3)
0.08
Angina n (%)
34 (21.52)
8 (28.57)
42 (22.58)
0.1
Leads with ST elevation
n
5.4±1.8
2.7±1.9
4.8±2.6
0.1
Leads with ST depression
n
4.8±2.6
3.2±2.4
4.3±2.4
0.2
ST depression in V1-V4 n (%)
85 (53.8)
12 (42.9)
97 (52.15)
0.07
Interval from symptoms onset
min
123.7±26.25
120.4±21.51
122.3±24.1
0.1
CPK IU
1656.8±373.4
1276.4±287.7
1465.4±325.7
0.1
LVEF %
46.21±7.8
48.37±8.2
48.5±8.0
0.2
CPK: Creatine Phosphokinase, LVEF: Left ventricular ejection fraction, IU: international unit

Table 2. Stepwise multivariate regression analysis for predicting the
correct diagnosis of acute myocardial infarction. The 15-lead ECG was
the sole factor associated significantly with the correct diagnosis.

5. DISCUSSION
The study showed that the addition of the 3 posterior
leads (V7, V8, and V9) to the standard 12 leads allows the
detection of ST elevation in more patients. Prompt STEMI
diagnosis is paramount for timely offered reperfusion
therapy. The findings of our study demonstrate the use-
fulness of the 15-lead ECG on the detection of posterior
and posterior-lateral AMIs, facilitating the decision for
reperfusion therapy. The preferred reperfusion strategy
is primary PCI. However, 60-70% of patients initially ar-
rive at non-PCI capable hospitals and therefore, throm-
bolysis should be administered (11).

It has previously been reported that approximately 11%
of patients (15% in our study) with ST elevation in the pos-
terior leads do not exhibit indicative abnormalities on
the classic 12-lead ECG (ST elevation or depression) that
would warrant the recording of additional leads (12).

The ECG sensitivity of STEMI diagnosis is increased
with the use of additional leads improving, as a result,
the prognosis of AMI patients (6, 13, 14). Of note, the sole
recording of the standard 12-lead ECG may subdiagnose
the posterior and right ventricular involvement in AMI,
as these leads do not directly reflect those segments. The
commonest additional leads are the posterior leads (V7,
V8 and V9) that view the posterior and lateral walls, and
the right V4 (RV4) that examine the right ventricle. There-
fore, the use of the 15-lead ECG may confirm the STEMI
diagnosis while determining its actual extent.

The term “posterior infarction” identifies an AMI that
insults the left ventricular wall by occlusion of the right
coronary artery–posterior descending branch or the cir-
cumflex artery (15). It accounts for 15-21% of all AMI (4, 5,
6, 13), often in conjunction with inferior or lateral ones.
The true posterior AMI is a rare entity, as it has been
shown in our study. Patients with inferior-posterior AMI
suffer from more severe AMI with lower left ventricular
is reportedly limited. Nonetheless, multiple studies have confirmed that the ECG diagnostic sensitivity and specificity for AMI is improved, and in doing so, facilitating the prompt application of the indicated reperfusion therapy (24). Moreover, the addition of the posterior leads offers more to the diagnosis of the posterior MI than the ECG changes on the V1-V3 leads (5, 6).

Extrapolating the findings of our study, it seems that patients with chest pain may benefit by the routine use of the 15-lead ECG, as demonstrated in those with AMI, and especially inferior AMI. It should be noted that the additional leads should be recorded by experienced personnel as misplaced electrodes may yield false diagnoses.

**Limitations:** The sample is relatively limited, which is fully justified by the rarity of the isolated posterior AMI and is comparable with similar published series.

**Clinical applications:** Based on the findings of the study, the routine use of 15-lead ECG for Emergency Department patients with chest pain should be supported and recommended.

6. CONCLUSION

The use of the 15-lead ECG contributes to a faster and more accurate diagnosis of STEMI facilitating the prompt reperfusion therapy.

- **Author’s contribution:** Ioannis Vogiatzis: led the writing of the protocol and the manuscript, conducted literature searches, and revised the paper. Efthamatis Koulouris: provided clinical experience and contributed to the paper. Antonios Ioannidis: provided clinical experience and contributed to the paper. Pavlos Roditis: provided clinical experience and contributed to the paper. Evangelos Stálikas: provided clinical experience and contributed to the paper. Ioannis Vogiatzis: led the writing of the manuscript.

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