# Evaluation of Age and Sex Dependent Criteria for ST Elevation Myocardial Infarction

PW Macfarlane[1], DR Hampton[2], E Clark[1], B Devine[1], CP Jayne[2]

[1]University of Glasgow, Scotland, UK
[2]Physio-Control, Redmond, WA, USA

## Abstract

*An evaluation of the Glasgow ECG analysis program criteria for acute ST elevation myocardial infarction (STEMI) was undertaken using two Board Certified cardiologists as the reference. Out of a data base of 1220 patients presenting with chest pain, 248 cases of confirmed MI were available for evaluation and 52 control cases were added from the remainder. The age and sex based Glasgow criteria were also assessed against existing ESC/ACC criteria.*

*Irrespective of whichever way the criteria were evaluated, the Glasgow age and sex based criteria proved to have a superior performance compared to the non age and sex based criteria. The overall sensitivity of the Glasgow criteria was 89% in a set of 219 patients with an MI, of whom 113 had a cardiologist reported STEMI. Evaluation of specificity in this population is not meaningful. The corresponding ESC/ACC criteria evaluated by computer were 75% sensitive.*

## 1. Introduction

Previous work from this laboratory has reported on the modification of criteria for acute myocardial infarction. In particular, criteria first suggested by the taskforce [1] of the American College of Cardiology (ACC) and the European Society of Cardiology (ESC) for the electrocardiographic diagnosis of acute myocardial infarction were made age and sex dependent [2]. The ESC/ACC criteria introduced the concept of reporting acute myocardial infarction when STj was elevated in two contiguous leads, where $ST_j$ had to exceed 0.2mV in V1-V3 or 0.1mV in all other leads. In respect of contiguity, V1 to V6 were regarded as contiguous whereas the limb leads were arranged in the sequence aVL, I, -aVR, II, aVF and III. This led to the term ST elevation myocardial infarction (STEMI).

Earlier work in this laboratory showed that normal limits of ST elevation were highly dependent on age, gender and ECG lead [3]. This resulted in locally revised criteria where ST amplitude limits of normality were made age and gender dependent for virtually every lead independently of the others [2].

The work of the lab in Glasgow has resulted in a modification to the most recent guidelines for universal myocardial infarction announced at the European Society of Cardiology meeting in Vienna in September, 2007 [4]. In these guidelines, the upper limit of normal in V2 and V3 was regarded as 0.2mV for males and 0.15mV for females while, for all other leads including V1, the upper limit of normal was set at 0.1 mV.

Notwithstanding the above, where the criteria are essentially designed for visual interpretation of the ECG, the University of Glasgow ECG analysis program continues to apply more complex criteria for ST elevation myocardial infarction. The aim of this present study was to extend comparisons of these locally developed age and sex based criteria with the original ESC/ACC criteria. In the previous publication [2], the accuracy of the program was compared with respect to the clinical classification of myocardial infarction. In the present paper, the results are assessed with respect to cardiologist based reporting of acute ST elevation myocardial infarction in addition to the clinical definition of MI.

## 2. Methods

A database of 1220, 12 lead ECGs was available from pre-hospital patients presenting with acute, non-traumatic chest pain. These ECGs were gathered from a North American population. 248 (20%) cases were positive for acute myocardial infarction according to classical criteria involving enzyme changes. Of these, 173 were male (mean age 66 years) and 75 were female (mean age 71 years).

The Glasgow Program [5] analysed all 12-lead ECGs using its well established measurement software. ST elevation was measured in several parts of the ST segment but for the purposes of applying the ESC/ACC criteria and indeed the Glasgow criteria for acute myocardial infarction, it was the ST amplitude at the J

Table 1. Sensitivities and selected specificities of the various criteria.

| | Cardiologist agreed STEMI (ESC/ACC criteria) | Cardiologist MI (professional opinion) | Clinically (Enzyme | Acute MI Based) |
|---|---|---|---|---|
| | Sensitivity (n=113) | Sensitivity (n=125) | Sensitivity (n=227) | Specificity (n=48) |
| Cardiologist MI (professional opinion) | | | 57% | 98% |
| Automated ESC/ACC Criteria | 75% | 73% | 42% | 96% |
| Automated age/sex adjusted ST-T criteria | 89% | 87% | 54% | 98% |

point ($ST_j$) which was used.

The software was programmed to use:

a) The ESC/ACC criteria for acute ST elevation/myocardial infarction (STEMI);

b) The Glasgow criteria for acute myocardial infarction involving age and sex based criteria for abnormal $ST_j$. These criteria have been described in part in the previous publication [2].

Two board certified US cardiologists reviewed a subset of 300 ECGs which contained all of the 248 cases of acute myocardial infarction together with 52 randomly selected controls. They agreed whether the ECGs met the ESC/ACC criteria by independently reporting all ECGs and then reaching consensus on any disagreements. They also separately used their professional judgement to report on the presence of acute myocardial infarction as evidenced by ECG changes.

## 3. Results

### 3.1. Cardiologist Defined Test Set

25/300 cases were excluded by the cardiologists agreeing on the presence of conduction defects. 4/25 cases were from the control group. Additional 8 cases were excluded from the cardiologist defined acute MI group because of cardiologist disagreement but they were included in the clinically diagnosed acute MI group. Thus in total 275 cases were included i.e. 48 controls and 227 patients with acute MI by enzymes in the clinically defined MI cohort though only 219 patients with clinically defined acute MI remained in the cardiologist defined test set because of the 8 disagreements.

### 3.2. Cardiologist Interpretation

Using the ESC/ACC criteria, the cardiologists identified 113/219 STEMIs. On the other hand, using their professional judgement, they identified 125/219 acute MIs including 11 that were in the non STEMI group. In addition, 1/48 control ECG was regarded as an acute MI.

### 3.3. Computer Interpretation

The Glasgow Program, applying ESC/ACC criteria, identified 85/113 of the cardiologist reported ESC/ACC STEMIs and 7 MIs among the non STEMIs i.e. 92/219 cases were reported as STEMI. However, by applying age and sex adjusted criteria, the Glasgow Program identified 101/113 of the cardiologist reported ESC/ACC STEMIs and 16 additional MIs among the non STEMIs i.e. 117/219.

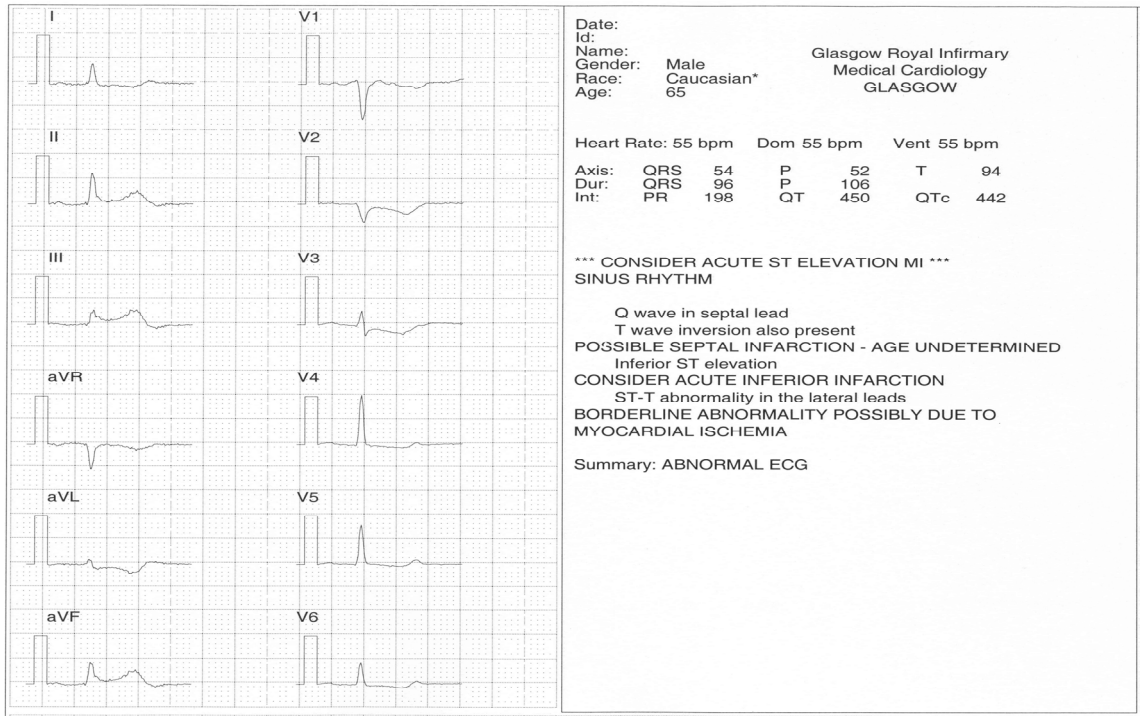
### 3.4. Summary

The sensitivity and specificity of the cardiologists and computer in detecting myocardial infarction is summarised in Table 1. It should be noted that the evaluation of specificity against cardiologist agreed STEMI or professional opinion is not meaningful given that all 219 patients in the cardiologist defined test set clinically had an acute myocardial infarction based on chest pain and enzyme results.

## 4. Discussion and conclusions

Several conclusions can be drawn from this study. First of all, it is quite clear that a computer program can be highly sensitive in replicating the diagnosis of cardiologist agreed acute myocardial infarction. There was little difference in this population in terms of

A: Output showing long text




B: Output showing short text

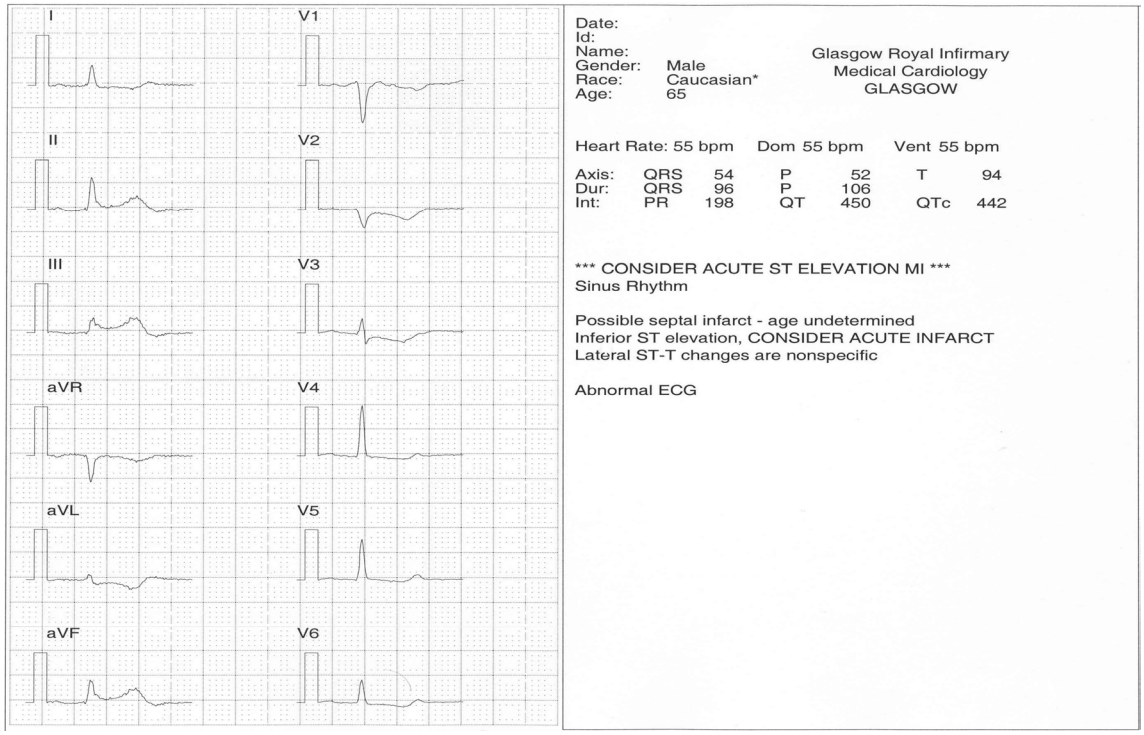



Figure 1. ECG where age/sex dependent, but not ESC/ACC criteria results in a diagnosis of STEMI.

sensitivity with respect to the cardiologist agreed STEMI (ESC/ACC) criteria versus cardiologist professional opinion. This does suggest that there were only a small number of cases with borderline ST elevation although it has to be recalled that all patients presented with chest pain – even the controls.

The second conclusion is that automated diagnoses are much more sensitive with respect to the cardiologist agreed cases of myocardial infarction as opposed to the clinically (enzyme based) cases of acute MI. Indeed there are substantial differences in sensitivity using either the original ESC/ACC criteria or the age/sex adjusted ST-T criteria developed in Glasgow. One reason for this is that the cardiologists themselves had a sensitivity of only 57% in reporting acute myocardial infarction in the population with proven myocardial infarction which indicates that there was a large group of non-STEMI patients.

It is also quite clear that the age/sex adjusted ST-T criteria are much superior to original ESC/ACC criteria which had no reference to age or gender. These criteria increased sensitivity with respect to both the cardiologist and the clinical diagnosis of myocardial infarction with no loss of specificity. It is therefore of interest that the ESC and the ACC have now agreed to move towards some acknowledgement of age and sex in developing criteria for acute myocardial infarction. Indeed, it is known that in a guideline paper dealing with acute myocardial infarction/ischaemia there will be further enhancement of these criteria which will introduce higher thresholds for ST elevation particularly for males under 40 years of age. Even then, such an adjustment will still not make the criteria as strongly dependent on age, sex and lead as those utilised by the Glasgow software.

Figure 1 illustrates an ECG where there is ST elevation in the inferior leads. However, based on the automated measurements, there are not two contiguous leads where STj exceeds 0.1mV in II, aVF and III, i.e. the ESC/ACC criteria are not positive. However, our own data suggest that the upper limit of normal STj for a 65 year old male is approximately 60 microvolts and in with other features also present in the lead, aVF would be regarded as abnormal for this ECG. Similar considerations also apply to II and III so that this ECG is regarded as showing an inferior STEMI according to the Glasgow criteria.

Two illustrations are provided. The first (A) uses long diagnostic statements suited for family practitioners for example. The second (B) use short statements more suited to hospital staff.

In conclusion, this study has provided further evidence that it is absolutely essential to structure criteria for diagnosing acute ST elevation myocardial infarction according to age and sex.

## References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Address for correspondence

Professor Peter W. Macfarlane,
Electrocardiology Group,
Faculty of Medicine – University of Glasgow,
Level 4, QEB,
Royal Infirmary,
10 Alexandra Parade,
Glasgow G31 2ER
Scotland, UK

peter.w.macfarlane@clinmed.gla.ac.uk