

# Critical Values in the Uni-G Program

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## Abstract

*Electrocardiograms may not be reviewed by a specialist for several hours after recording. This may lead to delayed clinical action in certain cases. To circumvent the problem, significantly abnormal ECGs are flagged through the provision of headline statements, sometimes known as critical values. The University of Glasgow ECG analysis program has been augmented to include 6 such headline statements. This significantly enhances the clinical utility of the software.*

## 1. Introduction

Millions of ECGs are recorded annually worldwide and nowadays, a high percentage have an automated report provided. Nevertheless, in many hospitals, it is the case that a physician reviews ECGs at a certain time of day and if an ECG has a significant abnormality that requires relatively quick clinical action, then there is a possibility that this could be delayed if the ECG abnormality is not brought to the attention of the relevant clinician as quickly as possible.

In order to circumvent the problem, the concept of introducing a series of headline statements has been proposed. This is not entirely new in the sense that, for example, a headline of “CONSIDER ACUTE STEMI” has been in use in the University of Glasgow Program [1] for some time [2]. However, it was felt that the number of such headline statements could be expanded in keeping with a trend towards the use of such statements.

## 3. Methods

A review was made of all of the statements in the University of Glasgow (Uni-G) ECG Analysis Program [1]. A number of statements were identified as being likely to lead to possible clinical intervention should they be printed as part of an ECG report.

Appropriate logic had to be developed so that when

one of these statements was identified, it led to the output of a headline statement at the top of the ECG report (Figure 1).

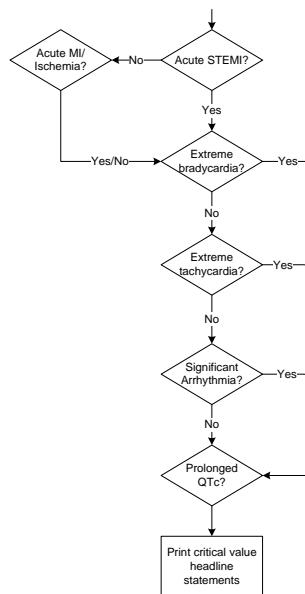


Figure 1. Decision process for generating headline statements.

## 4. Results

In total, six critical value statements were introduced. Each is described in the following sections.

### 4.1. Consider acute STEMI

The Glasgow software has for a number of years output a statement highlighting the presence of an acute myocardial infarction. Other vendors have similarly used such statements. Thus, this particular headline statement is not new. However, a new approach to highlighting the statement has been adopted. An example of this particular critical value statement is shown in Figure 2.

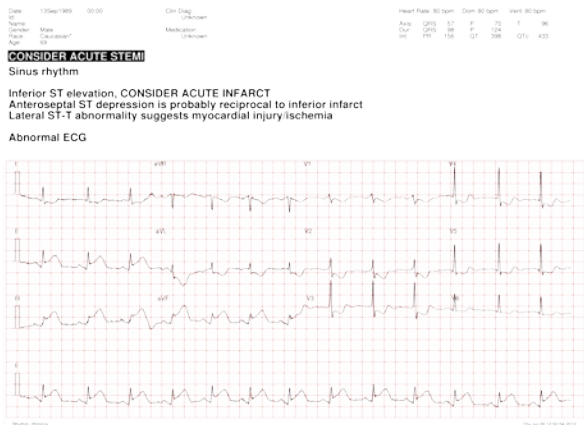


Figure 2. Example ECG showing headline statement “CONSIDER ACUTE STEMI”.

#### 4.2. Acute MI/ischemia

There are situations where the electrocardiogram can be significantly abnormal, with marked ST depression and T wave inversion suggestive of an acute incident which may or may not be part of an acute coronary syndrome. Current clinical guidelines tend to highlight only ST elevation. A specific treatment of this finding along with the presence of other clinical signs and symptoms, such as chest pain, is now well established [3]. However, these marked ST-T changes can similarly signify an acute incident and require to be highlighted, as shown in Figure 3.

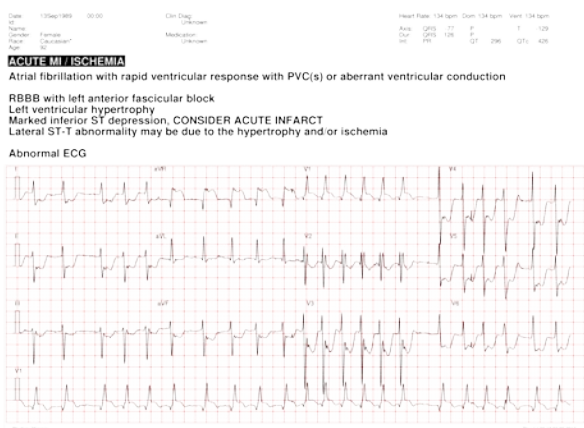


Figure 3. Example ECG showing headline statement “ACUTE MI/ISCHEMIA”.

#### 4.3 Extreme tachycardia

An increased heart rate is very often due to some form of underlying clinical problem and requires to be monitored. Upper limits of normal heart rate are age

related as neonates for example have a much higher normal rate than other individuals. The Glasgow software, therefore, has incorporated a statement Extreme Tachycardia which is output when heart rate exceeds an age based threshold for the upper limit of normal (Table 1) – see Figure 4. It should be noted that the program will also still report “SINUS TACHYCARDIA” for example in addition to the headline statement.

Table 1. Age related limits for reporting Extreme Tachycardia.

Age Range	Rate in Beats/min
Birth → 28 days	213 → 230
29 days → 180 days	230
181 days → 17 years	230 → 150
≥ 18 years	150

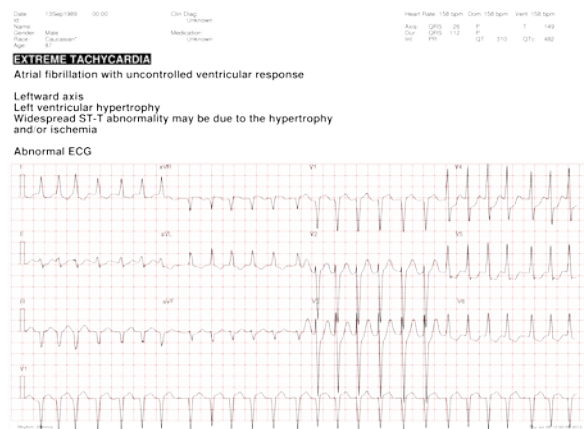


Figure 4. Example ECG showing headline statement “EXTREME TACHYCARDIA”.

#### 4.4. Extreme bradycardia

In the reverse situation, a slow heart rate likewise requires clinical review. There can be many causes of this abnormality and so it is advisable to highlight the finding in order to expedite the clinical review. As for tachycardia, an age dependent lower limit of heart rate (Table 2) is utilised in producing the statement of Extreme Bradycardia – see Figure 5.

Table 2. Age related limits for reporting Extreme Bradycardia.

Age Range	Rate in Beats/min
Birth → 28 days	73 → 90
29 days → 1 year	90
1 year → 6 years	90 → 45
6 years → 12.5 years	45 → 40
> 12.5 years	40

Date: 24Mar2008 09:05 Clin Diag: Other  
 Patient: Female  
 Gender: Male  
 Medication: No Medication  
 Age: 70  
 Heart Rate: 30 bpm QRS: 41 P: 20 T: 1.02  
 QTc: 475 QT: 328 QTcI: 476

**EXTREME BRADYCARDIA**  
 Sinus rhythm with 2:1 A-V block  
 Borderline prolonged QT interval  
 Inferior/lateral ST-T abnormality may be due to myocardial ischemia  
 Abnormal ECG

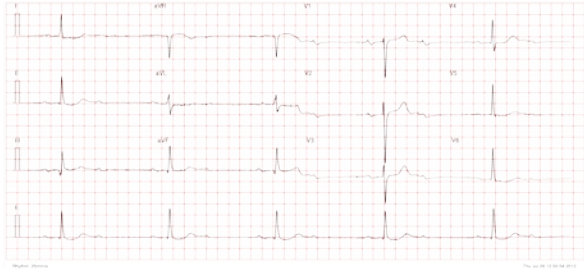


Figure 5. Example ECG showing headline statement “EXTREME BRADYCARDIA”.

#### 4.5. Significant arrhythmia

There are many abnormal rhythms, such as ventricular tachycardia or atrial fibrillation with uncontrolled ventricular response which require urgent medical attention. A large number of such statements in the Glasgow Program lead to the output of the headline “Significant Arrhythmia” (Table 3). In addition to those already mentioned, there are for example statements related to A-V dissociation, supraventricular tachycardia etc – see Figure 6.

Table 3. List of statements that trigger the headline statement “SIGNIFICANT ARRHYTHMIA”.

Rhythm Statement
Supraventricular tachycardia
Probable supraventricular tachycardia
Probable ventricular tachycardia
Consider ventricular flutter/fibrillation
Accelerated idioventricular rhythm
Possible idioventricular rhythm
Wide QRS tachycardia
Possible ventricular escape rhythm
Wide QRS tachycardia
A-V dissociation
with paroxysmal idioventricular rhythm
with multifocal interpolated PVCs
with frequent multifocal PVCs
with non-sustained ventricular tachycardia
with 2nd degree A-V block, Mobitz I (Wenckebach)
with 2nd degree A-V block, Mobitz II
with complete A-V block

Date: 25Jan2008 15:01 Clin Diag: Myocardial infarction  
 Patient: Male  
 Gender: Male  
 Medication: Other medication  
 Age: 60  
 Heart Rate: 45 bpm QRS: 48 P: 1.52 T: 1.09  
 QTc: 446 QT: 328 QTcI: 440

**SIGNIFICANT ARRHYTHMIA**  
 Sinus rhythm with 2nd degree A-V block, Mobitz I (Wenckebach)  
 Inferior infarct - age undetermined  
 Biventricular hypertrophy  
 Lateral ST-T abnormality may be due to the hypertrophy and/or ischemia  
 Abnormal ECG

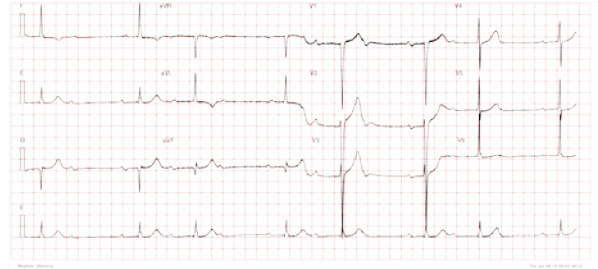


Figure 6. Example ECG showing headline statement “SIGNIFICANT ARRHYTHMIA”.

#### 4.6 Prolonged QTc interval

It is well known that a long QTc interval is related to life threatening arrhythmias. On the other hand, a certain tolerance in the estimation of QT interval has to be allowed to ensure that any warning of an abnormally long QT requiring immediate action is indeed due to a clearly abnormal QT interval. For this reason, a threshold value of 520ms for prolonged QTc has been chosen and an ECG with a QTc beyond this would result in the critical value statement being printed – see Figure 7. Some patients have a congenital long QTc but in such a situation, the attending physician would know that the finding was not of an acute nature. It does of course still remain a significant ECG abnormality.

Date: 21Aug2007 11:08 Clin Diag: Other  
 Patient: Female  
 Gender: Female  
 Medication: No Medication  
 Age: 12  
 Heart Rate: 40 bpm QRS: 112 P: 36 T: 1.1  
 QTc: 523 QT: 364 QTcI: 503

--- Interpretation based on pediatric criteria ---  
**EXTREME BRADYCARDIA** **PROLONGED QTc INTERVAL**  
 Sinus rhythm with varying 2nd degree A-V block  
 Prolonged QT - consider ischemia, electrolyte imbalance, drug effects  
 Widespread ST-T abnormality is nonspecific  
 Abnormal ECG

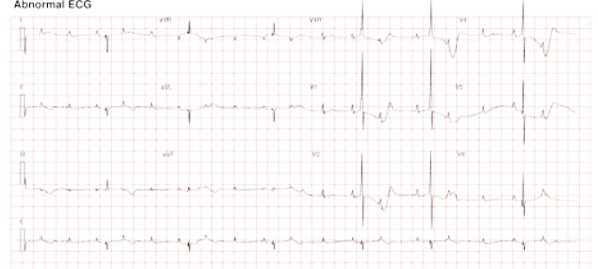


Figure 7. Example ECG showing headline statement “PROLONGED QTc INTERVAL”.

## 5. Conclusion

The addition of the critical value statements is seen as a significant enhancement to the Uni-G Program. At one point, it was suggested that ECG reports should be colour coded in that those coded green could be reviewed in a non urgent way, those coded yellow had to be reviewed within 4 hours, while those coded red had to be reviewed effectively as soon as possible. It is not known if this traffic light system was implemented widely.

In many hospitals outside of North America, electrocardiograms are not reported by cardiologists, and indeed in many cases, no reporting service is provided. A certain onus therefore is placed on the recording technician or nurse to bring to the attention of a physician, any significant abnormality that should be considered worthy of immediate clinical review. This places quite a responsibility on the recording staff, who may not be very experienced in electrocardiography. Therefore, the provision of critical value headline statements is an aid to such staff in deciding whether a clinician should be advised urgently of an ECG finding. As such, the approach is seen as an enhancement of the technique of automated ECG interpretation.

## References

- [1] Macfarlane PW, Devine B, Clark E. The University of Glasgow (Uni-G) ECG Analysis Program. *Computers in Cardiol* 2005;32:451-454.
- [2] Macfarlane PW, Browne D, Devine B, Clark E, Miller E, Seyal J, Hampton D. Modification of ACC/ESC criteria for acute myocardial infarction. *J Electrocardiol* 2004;37 (Suppl):98-103.
- [3] Thygesen K, Alpert JS, Jaffe AS, Simoons ML, Chaitman BR, White HD, the Writing Group on behalf of the Joint ESC/ACCF/AHA/WHF Task Force for the Universal Definition of Myocardial Infarction. Third universal definition of myocardial infarction. *Circulation*. 2012; DOI:10.1161/CIR.0b013e31826e1058.

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