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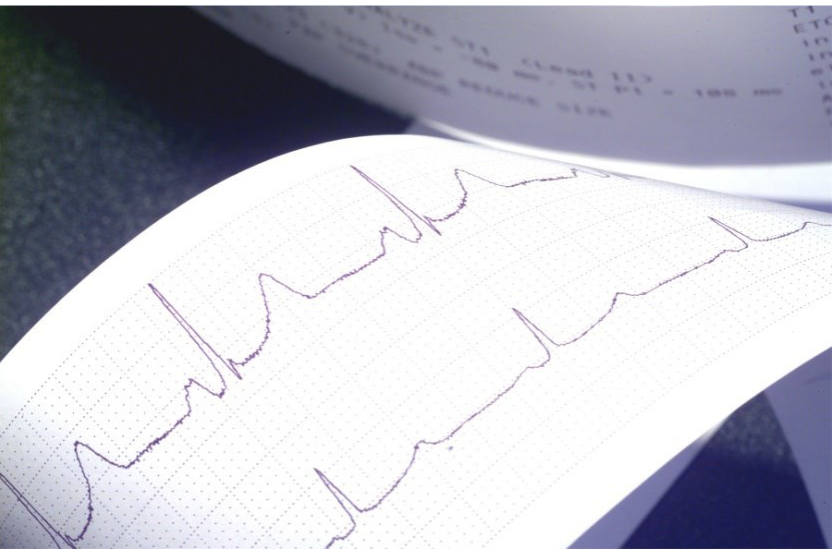
EN | PHYSICIAN'S GUIDE



# Glasgow 12-lead ECG Analysis Program

P/N 04145.02 | Version 1.0

GS Elektromedizinische Geräte
G. Stemple GmbH
Hauswiesenstraße 26
86916 Kaufering
Germany

CE 0123

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## Table of Contents

# 1 Intended Use

(IEC 60601-2-51 SECTION 50)

## 1.1 Diagnostic Application

The Glasgow Program is intended to provide an interpretation of the resting 12 lead ECG in all situations, whether this be in a hospital or primary care setting. It is capable of diagnosing all commonly recognized ECG abnormalities such as myocardial infarction (MI), including acute MI, ventricular hypertrophy, abnormal ST-T changes and common abnormalities of rhythm. Conduction defects and other abnormalities such as prolonged QT interval are also reported. The software is not designed for interpretation of exercise electrocardiograms. The software has been widely used in clinical trials, e.g. the West of Scotland Coronary Prevention Study[1] and hence has had wide exposure to recording of electrocardiograms in all commonly required situations.

## 1.2 Intended Population

The Glasgow Program is intended for use in adults and children of any age from birth upwards. The Program makes significant use of the patient's age and gender and indeed operates at the level of days in the case of neonates[2,3]. It is believed to be the only program that is based on normal limits derived using the algorithm itself with this applying to criteria for subjects of all ages, including neonates. Indeed, it is known that other developers utilize the Glasgow normal limits.

## 1.3 Intended Location

The Glasgow Program is intended to be used in hospital or in a general physicians office, or in out of hospital locations such as an ambulance. It is able to accept details of the patient's name, age, sex and race, and automatically invokes the appropriate criteria and routines such as special logic for acute myocardial ischaemia where necessary. There cannot be any difference in ECG appearances of acute myocardial infarction depending on the location of ECG recording – it is only the prevalence of the abnormality that will vary.

## 1.4 Diagnostic Accuracy

The program is designed to be as accurate as possible with the emphasis being, if anything, towards a high specificity given that the criteria are based on the normal limits already described. Nonetheless, the program has high sensitivity for detecting all cardiac abnormalities as is evidenced by the results presented in the following section. In short, the program aims for the highest sensitivity at a high specificity although there is always a trade off between one and the other.

1 Shepherd J, Cobbe SM, Ford I et al including Macfarlane PW.Prevention of coronary heart disease with Pravastatin in men with hypercholesterolemia.New Engl J Med 1995; 333: 1301-7

2 Macfarlane PW, Coleman EN, Pomphrey EO, McLaughlin S, Houston A, Aitchison TC.Normal limits of the high-fidelity pediatric ECG. Preliminary observations.J Electrocardiol 1989; 22(suppl): 162-8.

3 Macfarlane PW, Budgett S, Devine B, Aitchison TC.Paediatric ECG Analysis – The Glasgow ApproachIn: Electrocardiology 96 (ed) J. Liebman. 1997:451-460.

# 2 Directions for Users

## 2.1 Depiction of Warnings

**DANGER!**

A hazard with a high degree of risk which, if not avoided, will result in death or serious injury.

**WARNING!**

Computer assisted interpretation is a valuable tool when used properly. No automated analysis system is completely reliable, however, and interpretations should be reviewed by a qualified physician before treatment, or non-treatment, of any patient.

**CAUTION!**

A hazard with a low degree of risk which, if not avoided, may result in minor or moderate injury.

**NOTICE!**

Denotes a hazard with a low degree of risk which, if not avoided, may result in minor or moderate damage to property or the environment.

## 2.2 Depiction of Notes

Notes point out important information which the user must heed when carrying out an instruction. Notes provide the user with additional information on a particular issue.

# 3 Interpretation criteria

This section describes the criteria for interpretive statements. It is intended for expert users.

**WARNING!**

Computer assisted interpretation is a valuable tool when used properly. No automated analysis system is completely reliable, however, and interpretations should be reviewed by a qualified physician before treatment, or non-treatment, of any patient.

This guide sets out, in broad terms, the diagnostic criteria used by the University of Glasgow automated ECG analysis program. It is not possible to provide exact details of every criterion because various equations and procedures are involved which do not lend themselves to simple reproduction in this guide.

## 3.1 Measurement reference

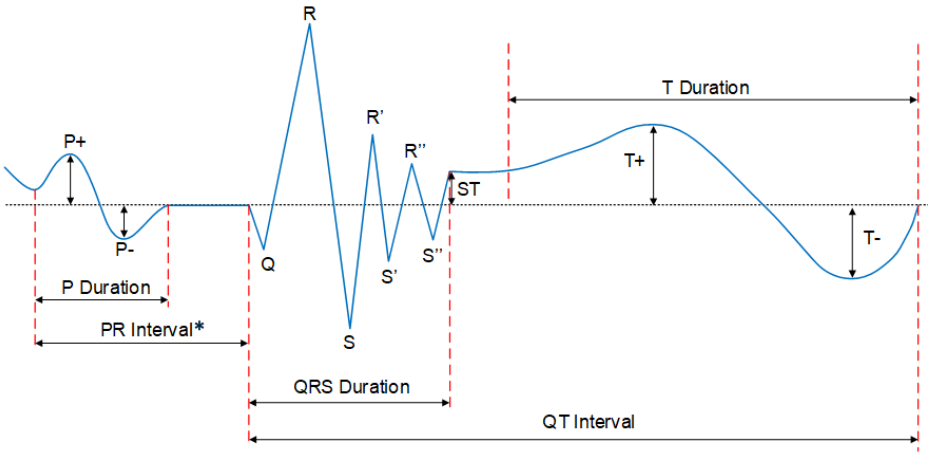
Overall P onset, P offset, QRS onset, QRS offset and T termination are determined from all 12 leads. Individual lead wave amplitudes are then obtained.

P+, P-, Q, R, S, R', S', R'', S'', ST, T+ and T- amplitudes are measured with respect to a horizontal line through the lead QRS onset.

Durations are measured between relevant points.

Areas are measured in units of millivolts x milliseconds but are scaled for storage and printout as µV.msecs/20. Units of measure are not specified when an area measurement appears in the criteria. For example, a printed value of 3259 in the measurement matrix corresponds to an actual area of 65180 µV.msecs.

Isoelectric components between the overall QRS onset and an individual lead onset are not included in a Q or R duration.




*PR Interval is identical to PQ

## 3.2 P and T wave morphologies

Throughout the handbook, the criteria may make reference to P or T wave morphologies where the morphology may be described as a number between –2 and +2. These morphologies refer to the wave shapes as follows:-

Morphology = +1

Morphology = -1

Morphology = +2

Morphology = -2

# 4 Preliminary comments

Advisory statements are included in the diagnostic output. The purpose of these statements is to supply information or give a warning about possible problems with the validity of the data. There are 4 main categories of preliminary comments: lead related (subdivided into two groups – lead validity and lead reversal/dextrocardia), rhythm related, demographic related and restricted analysis.

## 4.1 Lead related

**a) Validity**

This introductory section of the diagnostic software checks the validity of the leads. The criteria apply to ECGs recorded from patients of all ages.

**Criteria**

| | | | |
|---|---|---|---|
| A. | | I. | the QRS area in Vn is negative, |
| | | | and the QRS area in the leads on either side is positive |
| | or | II. | the QRS area in Vn < 25% of the area for Vn-1 and Vn+ 1, |
| | | | and all areas have the same sign |
| B. | | | \|QRS area\|> 500 in Vn-1, Vn, and Vn + 1 |
| C. | | I. | R amp in V2 + 0.025 < R amp in V1 |
| | and | II. | T+ amp in V1 > T+ amp in V2 + 0.025 |
| | and | III. | T+ amp in V3 > T+ amp in V2 + 0.025 |
| | and | IV. | T+ amp in V2 > 0 |
| D. | | I. | R amp in V1 - R amp in V2 > 0.2mV |
| | and | II. | R amp in V3 - R amp in V2 > 0.2mV |
| | and | III. | \|T- amp in V2\| > T+ amp in V2 |
| E. | | I. | T+ amp in V1 > \|T- amp in V1\| + 0.025 |
| | and | II. | \|T- amp in V2\| > \|T+ amp in V2\| + 0.025 |
| | and | III. | T+ amp in V3 > \|T- amp in V3\| + 0.025 |
| F. | | I. | R amp in V1 > R amp in V2 + 0.4mV and R' amp in V2 = 0 |
| | and | II. | R amp in V3 > R amp in V2 + 0.4mV and R' amp in V2 = 0 |
| G. | | | QRS area in V1 < 0 and QRS area in V2 > 0 |
| | | | and QRS area in V3 < 0 and QRS area in V4 > 0 |
| H. | | I. | R amp in V2 > R amp in V3 + 200 |
| | or | II. | \|S amp in V1\| > \|S amp in V2\| * 3 |
| | | | and \|S amp in V3\| > \|S amp in V2\| * 3 |
| I. | | I. | max (R,R') amp in V2 > 2.5* max (R,R') amp in V1 |
| | | | and max (R,R') amp in V4 > 2.5* max (R,R') amp in V3 |
| | and | II. | max (R,R') amp V2 > max (R,R') amp V3 + 300 |
| J. | | I. | There is no Q in V2 |
| | and | II. | There is not (R' in V1 and V2 but not in V3) |
| K. | | | There is not a Q in V1 where \|Q\| > 0.075mV |

**Statements**

1. Possible faulty Vn – omitted from analysis

   For leads V2-V5:

   (a) I. peak-peak QRS in any one of V2 to V5 < 0.35mV
   and < 1/3 peak-peak QRS of the leads on either side
   or II. if the peak to peak QRS in any one of V2 to V5 < 0.5 mV
   and < 1/5 peak-peak QRS of the leads on either side

   and (b) T+ < 0.10 mV with T- > -0.10 mV in that lead

2. Possible faulty V6 – omitted from analysis

   (a) peak-peak QRS in V6 < 0.3 mV,
   and < 1/3 peak-peak QRS in V5

   or (b) peak-peak QRS in V6 < 0.5 mV,
   and < 1/6 peak-peak QRS in V5

   or (c) if P+ = 0 in V6 with QRS area in V6 < -200
   and QRS area in V5 > 200

3. Possible sequence error: V1, V2 omitted

   (a) C or D or E or F is true

   and (b) K is true

4. Possible sequence error: V2, V3 omitted

   (a) I. G and H are true
   or II. I is true

   and (b) J is true

5. Possible sequence error: Vn, Vn+1 omitted

   For leads V3-V5

   (a) A and B are true

6. V1/V2 are at least one interspace too high and have been omitted from the analysis

   (a) |P-| > 0.05mV in leads V1 and V2

   and (b) 0.5mV >|R'|> |R|> 0.045mV in lead V2

   and (c) I. 0.5mV >|R'|> |R|> 0.045mV in lead V1
   or II. |R'| = 0mV in lead V1

   and (d) |T-|> 0.05mV in leads V1 and V2

7. Lead(s) unsuitable for analysis

If any of the leads is not present, the above statement is printed with the appropriate lead identified.

8. --- Possible measurement error ---

The maximum absolute value of the P+ or P- wave in any lead exceeds 1.0mV.

**b) Lead reversal/dextrocardia**

This section of the program aims to detect faulty application of the limb leads and to differentiate this from dextrocardia. The criteria are age dependent and allowance has to be made for the fact that Lead V3 may not be available in children.

**Criteria**

| | | | |
|---|---|---|---|
| A. | | | the P wave flag is set |
| B. | | | 85° < P axis ⩽ 180° or -180° ⩽ P axis < -85° |
| C. | | | 85° < QRS axis ⩽ 180°, or -180° ⩽ QRS axis < -85° |
| | | | and (the QRS area in Lead I is negative |
| | | | or [R duration >= 40ms and Q duration >= 40ms]) |
| D. | | | in V6, the peak to peak QRS > 0.5 mV, with the QRS area > 0 and P+ > P- and (R amp in lead I < 0.2mV or there is a Q wave in lead I) |
| E. | | I. | 0 ⩽ R(n+1) ⩽ R(n) for n = V3, V4, V5 |
| | | | or R ⩽ 0.1 mV for all of V3, V4, V5, V6 |
| | and | II. | 100 > QRS area (n+1) > QRS area(n) for n = V3, V4, V5, and in V6, peak to peak QRS < 0.8 mV, with R < 0.1 mV, and QRS axis > 60° |
| F. | | I. | in I, \|Q\|> R ⩾ R', or (\|S\| > R', with Q = 0 and \|S\| > R+100 |
| | and | II. | in V6, S > 0.25 mV or \|R/S\| ⩾ 2 |
| | and | III. | ST polarities are opposite in I and V6 as are T wave amplitudes |
| G. | | | R and R' amplitude < 0.135 mV |
| H. | | | \|S\| and \|S'\| amplitude < 0.05 mV |
| J. | | | Q\| < 0.06 mV |
| K. | | | \|QRS area in lead I + QRS area in lead III\| < |
| | | | \|QRS area in lead II\| + 50 |
| L. | | | T+ + \|T-\| < 0.07 mV |
| M. | | | \|QRS area in lead II - QRS area in lead I\| < |
| | | | \|QRS area in lead III\| + 50 |
| N. | | | 90° < T axis ⩽ 180° or -180° ⩽ T axis ⩽ -90° |
| | | | and P- amplitude in lead I < -0.1 |
| | | | and QRS area in lead I < -500 |
| | | | and T- amplitude in lead I < -0.05 |
| O. | | | P+ amplitude < 0.075 |
| P. | | | \|QRS area in lead II - QRS area in lead III\| < |
| | | | \|QRS area in lead I\| + 50 |
| Q. | | I. | -180° < P axis ⩽ -90° |
| | and | II. | -90° ⩽ QRS axis < -30° |
| | and | III. | -90° = T axis < 0° |
| | and | IV. | $\sum$ \|P-\| over leads I, II, III > 200 |
| | and | V. | heart rate < 120 bpm |

**Statements**

1. --- Possible arm lead reversal – hence only aVF, V1 – V6 analyzed ---

| | | | |
|---|---|---|---|
| | (a) | | A and B and C and (D or F or N) true and E false and age > 180 days |
| or | (b) | | C and F true and (not A) and age > 180 days |
| or | (c) | | A and B and { $\sum$ TI x $\sum$ TV6 < 0 } and age ⩽ 180 days where $\sum$ TI = TI+ - \|TI- \| and T+ is the amplitude of the positive component of the T wave and T- is the amplitude of negative component of the T wave. |

2. --- Suggests dextrocardia ---

| | | | | |
|---|---|---|---|---|
| | (a) | | | 1 is not true |
| and | (b) | | I. | A and B and E are true |
| | | or | II. | (not A) and C and E are true |

3. --- Possible limb lead reversal – hence only V1-V6 analyzed ---

| | | | | |
|---|---|---|---|---|
| | (a) | | I. | G, H, J, L and O are true for lead II |
| and | | | II. | K is true |
| or | (b) | | I. | G, H, J, L and O are true for lead III |
| | | and | II. | M is true |
| or | (c) | | I. | G, H, J, L and O are true for lead I |
| | | and | II. | P is true |

4. --- Possible arm/leg lead interchange – hence only V1-V6 analyzed ---

| | | |
|---|---|---|
| | (a) | Q is true |

## 4.2 Rhythm related

If there is an arrhythmia which results in abnormal ventricular conduction, e.g. VT, the diagnostic report may not be valid. In this case, the following statement will be printed.

1. If rhythm is confirmed, the following report may not be valid.

## 4.3 Demographic related

The following statements can be printed in the event of faulty input of clinical data or in the event of missing demographic data. Analysis continues with default values chosen. In addition, there is a statement to indicate if pediatric criteria is being used.

1. --- Invalid clinical data entry ---

| | | |
|---|---|---|
| | (a) | clinical classifications are normal + any other |
| or | (b) | clinical classifications are unknown + any other |

2. --- Invalid medication entry ---

| | | |
|---|---|---|
| | (a) | drugs are unknown + any other |

corpuls3 does not support drugs as an input.

3. --- Interpretation made without knowing patient's gender ---
4. --- Interpretation made without knowing patient's age ---
5. -- Interpretation made without knowing patient's gender/age --
6. --- Interpretation based on pediatric criteria ---
   (a) the patient is under 18 years of age

## 4.4 Restricted analysis

If it is not meaningful to interpret the QRS-T morphology for whatever reason, one of the following statements will be printed.

1. Pacemaker rhythm – no further analysis
2. --- No further analysis due to lack of dominant QRS ---
3. --- Similar QRS in V leads ---
4. --- Technically unsatisfactory tracing ---

# 5 Heart rate

The limits for tachycardia and bradycardia are clearly age related in the neonatal and paediatric age range. In the program, a continuous limit of normality is used for certain age ranges such as from birth to 28 days (see example below). These data were obtained from a study of over 1,750 healthy neonates, infants and children.

## 5.1 Tachycardia

| Age range * | Rate in beats / min |
|---|---|
| Birth - 28 days | 163 → 180 |
| 29 days - 180 days | 180 |
| 181 days - 17 years | 180 → 100 |
| ⩾ 18 years | 100 |

* corpuls3 does not support age entry in days.

## 5.2 Bradycardia

| Age range * | Rate in beats / min |
|---|---|
| Birth - 28 days | 88 → 105 |
| 29 days - 365 days | 105 |
| 1 year (366 days)<br>– 6 years (2191 days) | 105 → 60 |
| 6 years (2192 days)<br>– 12.5 years (4600 days) | 60 → 50 |
| > 12.5 years (4600 days) | 50 |

N.B. The final limits of 100 and 50 are user programmable.

Example: For a neonate of 14 days of age,
the tachycardia limit is 172/min and the bradycardia limit is 96/min.

* corpuls3 does not support age entry in days.

## 5.3 Marked sinus bradycardia

If the heart rate is less than 40bpm, then marked sinus bradycardia is reported.

# 6 Intervals

The normal limit of PR interval is age dependent and the appropriate continuous equation is utilised in the software. To control specificity, it was decided to maintain the upper limit of normal for adolescents and adults at 200ms although there is evidence that it may be slightly less than this value particularly in the younger of these age groups.

Since QT interval is essentially heart rate related, an age dependent equation has not been utilised. However, if the heart rate exceeds 125 per minute, no statement on corrected QT interval is printed. This approach also applies if the QRS duration is in excess of 120ms.

## 6.1 PR interval

Omit this section if:

(a) the P wave flag (from rhythm analysis) is not set,

or (b) the rhythm is not Sinus rhythm,

or (c) WPW pattern is present

**Statements**

1. Short PR Interval

(a) the PR interval is less than the lower limit for age as specified in the table

| Age | Limit in ms |
|---|---|
| 0-15 years | 75 + 0.006 * Age (days) |
| 16+ years | 110 |

2. with 1st degree A-V block

(a) The PR interval ⩾ the age dependent limit as specified in the table.

| Age | Limit in ms |
|---|---|
| ⩽ 18 years | 163 + 0.0087 * Age (days) |
| > 18 years | 220 |

3. with borderline 1st degree A-V block

(a) 2(a) is not true.

and (b) The PR interval ⩾ the age dependent limit as specified in the table.

| Age | Limit in ms |
|---|---|
| ⩽ 18 years | 143 + 0.0087 * Age (days) |
| > 18 years | 200 |

The statements 2 and 3 are determined by the rhythm analysis.

## 6.2 QT interval

If the QRS duration ⩾ 120ms, or if the heart rate exceeds 125/minute, omit this section. The criteria in this section use the corrected QT interval denoted QTc. The particular formula for computing QTc is user selectable and can be one of the following:-

Hodges[1] $$QTc = QT + 1.75 \times (HeartRate - 60)$$

Bazett[2] $$QTc = QT \times \left( \frac{HeartRate}{60} \right)^{\frac{1}{2}}$$

Fridericia[3] $$QTc = QT \times \left( \frac{HeartRate}{60} \right)^{\frac{1}{3}}$$

Framingham[4] $$QTc = QT + 154 \times \left( 1 - \frac{60}{HeartRate} \right)$$

If there is no facility for the user to select which QTc formula is to be used, the Hodges QTc formula will be used by default.[5]

**Statements**

1. Borderline prolonged QT interval

| | | | |
|---|---|---|---|
| | (a) | | infant < 6 months and 500ms ⩽ QTc < 520ms |
| or | (b) | | male and age > 6 months and 460ms ⩽ QTc < 480ms |
| or | (c) | | female and |
| | | I. | age ⩾ 50 years and 470ms ⩽ QTc < 490ms |
| | or | II. | 6 months < age < 50 years and 460ms ⩽ QTc < 480ms |

2. Prolonged QT – consider ischemia, electrolyte imbalance, drug effects

| | | | |
|---|---|---|---|
| | (a) | | infant < 6 months and QTc ⩾ 520ms |
| or | (b) | | male and age > 6 months and QTc ⩾ 480ms |
| or | (c) | | female and |
| | | I. | age ⩾ 50 years and QTc ⩾ 490ms |
| | or | II. | 6 months < age < 50 years and QTc ⩾ 480ms |

1 Hodges M, Salerno D, Erlien D. Bazett's QT correction reviewed. Evidence that alinear QT correction for heart rate is better. J Am Coll Cardiol 1983;1:694.

2 Bazett HC. An Analysis of the time relations of electrocardiograms. Heart 1920; 7:353-370.

3 Fridericia LS. Die Systolendauer im Elektrokardiogramm bei normalen Menschen und bei Herzkranken. Acta Med Scan 1920;53:469-486.

4 Sagie A, Larson MG, Goldberg RJ, et al. An improved method for adjusting the QT interval for heart rate (the Framingham Heart Study). Am J Cardiol 1992;70:797-801.

5 Luo S, Michler K, Johnston P, Macfarlane PW. A comparison of commonly used QT correction formulae: the effect of heart rate on the QTc of normal ECGs. J Electrocardiol 2004;37(suppl):81-90.

copruls3 does not support drugs as an input.

3. Short QT interval

(a) QTc ⩽ 350ms

# 7 Atrial abnormalities

If the P wave flag is not set, or rhythm is not sinus, omit this section.

**Criteria**

| | | | | |
|---|---|---|---|---|
| A. | | | | P duration ⩾ 150ms |
| B. | | | | P+ amplitude > 0.3mV in any one of II, III, aVF. |
| C. | | | I. | P- amplitude in V1 ⩽ -0.15mV |
| | | and | II. | P terminal duration in V1 ⩾ 40ms |
| D. | (a) | | I. | age > 30 days |
| | | and | II. | P+ in V1 > 0.20mV |
| | | or | III. | P+ in V2 > 0.225mV |
| or | (b) | | I. | age ⩽ 30 days |
| | | and | II. | P+ in V1 > 0.25mV |
| | | or | III. | P+ in V2 > 0.25mV |

**Statements**

1. Possible right atrial abnormality

| | | | | |
|---|---|---|---|---|
| | (a) | | | B is true |
| or | (b) | | I. | D is true |
| | | and | II. | A is false |
| | | and | III. | clinical classification is not respiratory disease |

2. Consider left atrial abnormality

| | | | | |
|---|---|---|---|---|
| | (a) | | | A is true |
| and | (b) | | | D is false |

3. Possible right atrial abnormality consistent with pulmonary disease

| | | | | |
|---|---|---|---|---|
| | (a) | | | D is true |
| and | (b) | | | A is false |
| and | (c) | | | clinical classification is respiratory disease |

4. Possible left atrial abnormality

| | | | | |
|---|---|---|---|---|
| | (a) | | | C is true |
| and | (b) | | | D is not true |

5. Possible biatrial enlargement

| | | | | |
|---|---|---|---|---|
| | (a) | | | D is true |
| and | (b) | | | A or C is true |

# 8 QRS axis deviation

**Statements**

The section on frontal plane abnormalities is omitted if one of Leads I, II, III is not available or if WPW is present. The following age dependent equation is used to calculate the upper limit of normal QRS axis for patients with an age ⩽ 6 months.

LIM = [230 - (0.66*age (days)].

The maximum value of LIM is set at 110° for all patients over the age of 6 months.

1. Indeterminate axis

| | | | | |
|---|---|---|---|---|
| | (a) | | | The (algebraic) sum of the amplitudes of Q, R and S < 0.15mV in Leads I, II and III. |
| | | | | If the above statement is true, omit the remainder of this section. |

2. Leftward axis

| | | | | |
|---|---|---|---|---|
| | (a) | | I. | age > 30 years |
| | | and | II. | -30° < overall QRS axis ⩽ -20° |
| or | (b) | | I. | 15 ⩽ age ⩽ 30 years |
| | | and | II. | QRS axis < (15 - age (years)) * 2 + 10 |

3. Left axis deviation

| | | | | | |
|---|---|---|---|---|---|
| | A. | | | | RBBB WITH LEFT ANTERIOR FASCICULAR BLOCK is NOT present |
| and | B. | (a) | | I. | age > 30 years |
| | | | and | II. | -45° < overall QRS axis ⩽ -30° |
| | | | and | III. | QRS area in aVF < 0 |
| | or | (b) | | I. | 15 ⩽ age ⩽ 30 years |
| | | | and | II. | QRS axis < (15 - age (years)) * 2 |

4. Marked left axis deviation

| | | | | |
|---|---|---|---|---|
| | (a) | | | RBBB WITH LEFT ANTERIOR FASCICULAR BLOCK is NOT present |
| and | (b) | | I. | -120° ⩽ overall QRS axis ⩽ -45° |
| | | and | II. | QRS area in aVF < 0 |

5. QRS axis leftward for age

| | | | | | |
|---|---|---|---|---|---|
| | A. | | | | RBBB WITH LEFT ANTERIOR FASCICULAR BLOCK is NOT present |
| and | B. | (a) | | I. | age < 7 days |
| | | | and | II. | -120° < overall QRS axis < 75° |
| | | | and | III. | (QRS axis < 0° and QRS area aVF > 0) is not true |
| | | or (b) | | I. | 7 days ⩽ age ⩽ 182 days |
| | | | and | II. | -120° < QRS axis < 78° -(78*Agedys)/182 |
| | | or (c) | | I. | 183 days ⩽ age < 15 years |
| | | | and | II. | -120° < QRS axis < 0° |

6. Rightward axis

| | | | | |
|---|---|---|---|---|
| | (a) | | I. | age ⩾ 182 days |
| | | and | II. | 90° < overall QRS axis < LIM |

7. Right axis deviation

(a) LIM ⩽ overall QRS axis < max (LIM + 10°, 180°)
(usually 110° → 120° for age > 6 months)

8. Marked right axis deviation

(a) LIM +10 ⩽ overall QRS axis < max (LIM + 20°, 180°)
(usually 120° → 180° for age > 6 months)

9. Left anterior fascicular block

(If all the following criteria are met, this statement replaces Nos. 2, 3,4 and 5)

(a) LBBB or RBBB WITH LEFT ANTERIOR FASCICULAR BLOCK or IVCD are not present
and (b) There is no inferior infarct or extensive infarct
and (c) R amplitude > 0 in Lead II
and (d) The QRS complexes in leads aVR and aVL each end in an R wave
and (e) The peak of the terminal R wave in lead aVR
occurs later than the peak of the terminal R wave in lead aVL
and (f) -120° < QRS axis ⩽ -45°

10. Possible left anterior fascicular block

(a) 9(a) to 9(e) are true
and (b) -45° < QRS axis < -30°

11. Possible left posterior fascicular block

(If all the following criteria are met, this statement replaces Nos. 6,7 and 8).

(a) RVH is not present
and (b) I. 90° < QRS axis < 180° and age ⩾ 30 years
or II. 105° < QRS axis < 180° and age < 30 years
and (c) QRS duration < 120ms
and (d) R or R' in lead II > 0.8mV
and (e) R or R' in lead III > 1mV
and (f) Q ⩽ -0.02mV in leads II and III

12. Severe right axis deviation

(a) max (LIM + 20°, 180°) < overall QRS axis < 240°
(normally 180° → 240° for age > 6 months)

# 9 Conduction defects

The duration criteria for conduction defects are age dependent. As indicated in the Introduction, it is possible to utilise an equation to calculate the upper normal limit of QRS duration from birth to adolescence and a similar concept can be applied to determine the normal limits of the duration of Q, R, S waves individually. In order not to complicate the criteria listing, certain duration values are listed as a constant value plus an age dependent variable denoted by LIM1 or LIM2 or LIM3. The following table lists the values of these three variables at birth and in adolescence. Adult criteria are obtained by using the higher of the values while paediatric criteria are derived from an age dependent value intermediate to the two limits.

| | Birth | Adolescence |
|---|---|---|
| LIM1 | 0 ms | 32 ms |
| LIM2 | 29 ms | 35 ms |
| LIM3 | 40 ms | 45 ms |

As an example, Criterion 1a indicates that the R or R' duration in Lead I has to exceed 68ms at birth or 100ms in adulthoood for the criterion to be met, while at age 10, the critical duration would be approximately 85ms.

Although constant values are specified in the criteria, the discrete thresholds between normal and abnormal have been replaced by continuous functions. These functions were introduced to improve the repeatability of the program. Algebraic rules have been used to combine criteria.

**Statements**

1. Left bundle branch block

| | | | | |
|---|---|---|---|---|
| A. | (a) | | | the QRS spatial velocities at any two of 4/8, 5/8 and 6/8 < 100 mV/sec |
| and | (b) | | I. | in Lead I, V5 or V6:R > LIM1 + 68ms, with Q > -0.02mV |
| | | or | II. | in Lead I, V5 or V6: R' > LIM1 + 68ms, with S > -0.02mV |
| and | (c) | | | in V1, either Q or S ⩾ LIM1 + 58ms with amplitude < -1 mV |
| and | (d) | | | (R+R') duration summed over I, V5 and V6 > 3*(LIM1 + 58ms) |
| and | (e) | | | R amplitude/R duration < 20 in I and (V5 or V6) with \|R/S\| > 4 |
| and | (f) | | | QRS duration ⩾ LIM1 + 88ms in any two leads |
| and | (g) | | | in V2, sum of R+R' < 0.3mV |

| | | | | |
|---|---|---|---|---|
| or | B. | | | 1A and 6A are false and from the following criteria either: |
| | | | | (a and b and c and d and f) |
| | | or | | (b and d and e and f) is true |
| | | (a) | | QRS duration > LIM1 + 88ms in any two leads |
| | | (b) | I. | in Lead I, V5 or V6: R > LIM1 + 68ms, with Q > -0.02mV |
| | | or | II. | in Lead I, V5 or V6: R' > LIM1 + 68ms, with S > -0.02mV |
| | | (c) | I. | in Lead I, S ⩽ LIM2, or S ⩾ -0.15mV, or \|R/S\| ⩾ 4 |
| | | and | II. | in Lead I, S' ⩽ LIM2, or S' ⩾ -0.15mV, or \|R'/S'\| ⩾ 4 |
| | | (d) | | in V1 or V2, either Q or S > LIM1 + 68ms, |
| | | | | with corresponding amplitude < -1.0mV |
| | | (e) | | the QRS spatial velocity at 4/8 and 5/8 < 100mV/sec |
| | | (f) | | (R+R') duration summed over I, V5 and V6 > 3*(LIM1 + 58ms) |

2. Incomplete LBBB

| | | | | |
|---|---|---|---|---|
| | | (a) | I. | in V5 or V6, R > LIM1 + 38ms, with Q > -0.02mV |
| | | or | II. | in V5 or V6, R' > LIM1 + 38ms, with S > -0.02mV |
| and | (b) | | I. | in V5 or V6, 100ms < QRS < 130ms |
| | | and | II. | in V1 or V2, 100ms < QRS < 130ms |
| and | (c) | | | the QRS spatial velocities at 4/8 and 5/8 < 100mV/sec |
| and | (d) | | I. | in I, S ⩽ LIM2, or S ⩾ -0.15mV or \|R/S\| > 4 |
| | | and | II. | in I, S' ⩽ LIM2, or S' ⩾ -0.15mV or \|R'/S'\| > 4 |
| and | (e) | | I. | in V1 and V2, R and R' > LIM3 + 15ms |

3. Right bundle branch block

| | | | | |
|---|---|---|---|---|
| | A. | (a) | | QRS duration in V5 or V6 > LIM1 + 68 ms, |
| | | | | and QRS duration in V1 or V2 > LIM1 + 68 ms |
| and | (b) | | I. | in I, V5 or V6, S > LIM2, and S < -0.14 mV, and \|R/S\| < 4 |
| | | or | II. | in I, V5 or V6, S' > LIM2, and S' < -0.14 mV, and \|R'/S'\|< 4 |
| and | (c) | | | in V1 or V2, R or R' > 45 ms |
| and | (d) | | I. | the QRS spatial velocity at 4/8 or 5/8 < 40 mV/sec |
| | | or | II. | the QRS spatial velocity at 6/8 < 40 mV/sec with the QRS spatial velocity at 6/8 less than at 7/8 |
| and | (e) | | | in V1, T- < -0.1 mV |
| and | (f) | | | QRS axis is not between -30° and -120° or R > \|S\| in II |
| and | (g) | | I. | QRS axis is not between 100° and 135° |
| | | or | II. | R and R' in Lead II < 0.8 mV |
| | | or | III. | R and R' in Lead III < 1 mV |
| | | or | IV. | RVH is present |
| and | (h) | | | QRS duration > LIM1 + 78 ms in any two leads |
| and | (i) | | | WPW is not present |
| and | (j) | | | Brugada pattern is not present |

| | | | | |
|---|---|---|---|---|
| or | B. | | I. | (a and b and c) or (d and e) |
| | | and | II. | (f) is true |
| | | and | III. | Brugada pattern is not present |
| | (a) | | I. | QRS duration > LIM1 + 78 ms in any two leads |
| | | and | II. | QRS duration > LIM1 + 83 ms or RVH is not present |
| | (b) | | | in Lead V1 or V2, R > LIM3 with S = 0, or R' > LIM3 |
| | (c) | | I. | in Lead I, S, S' and R all have 0 amplitude, and Q is not 0 |
| | | or | II. | in Lead I, V5 or V6, S > LIM2, and S < -0.14 mV or \|R/S\| < 4 |
| | | or | III. | in Lead I, V5 or V6, S' > LIM2, and S'< -0.14 mV or \|R/S'\| < 4 |
| | (d) | | | R or R' in Lead V1 > LIM1 + 88 ms |
| | (e) | | | delta confidence value in Lead V1 is 0 |
| | (f) | | | QRS axis is not between -30° and -120° or R > \|S\| in II |
| | (g) | | I. | QRS axis is not between 100° and 135° |
| | | or | II. | R and R' in Lead II < 0.8 mV |
| | | or | III. | R and R' in Lead III < 1 mV |
| | | or | IV. | RVH is present |

4. RBBB with left anterior fascicular block

| | | | | |
|---|---|---|---|---|
| | | | | Test (a) below replaces tests (f), (h) in RBBB part A |
| | | or | | Test (a) below replaces tests (f) in RBBB part B |
| | (a) | | I. | -120° < overall QRS axis < -30° and R ⩽ \|S\| in II |
| | | and | II. | Inferior myocardial infarction is not present |

5. RBBB with RAD - possible left posterior fascicular block

| | | | | |
|---|---|---|---|---|
| | | | | Test (a) below replaces (g), (h) in RBBB part A |
| | | or | | Test (a) below replaces (g) in RBBB part B |
| | (a) | | I. | 100° ⩽ overall QRS axis ⩽ 135° and age > 6 months |
| | | and | II. | R or R' in Lead II ⩾ 0.8 mV |
| | | and | III. | R or R' in Lead III ⩾ 1 mV |
| | | and | IV. | RVH is not present |

6. IV conduction defect

Either A or B is true

| | | | |
|---|---|---|---|
| A. | (a) | | in Lead I, R or R' > LIM1 + 68 ms |
| and | (b) | | in Lead I, T+ < 0.1 mV and T- < -0.1 mV |
| and | (c) | | in V1, R or R' > LIM3 |
| and | (d) | | the QRS spatial velocity at 4/8 or 5/8 < 40 mV/sec |
| and | (e) | | in V1, both Q and S have duration ⩽ LIM1 + 68 ms |
| | | | or amplitude ⩾ -1 mV |
| and | (f) | | Brugada pattern is not present |

| | | | | |
|---|---|---|---|---|
| B. | | | | Statement 1 to 5 are false, Brugada pattern is not present and from the following criteria either: |
| | | | | (a) is true |
| | | or | | (b and c) is true. |
| | (a) | | | QRS duration ⩾ LIM1 + 88 ms in any two leads |
| | (b) | | | in V1 or V2, Q or S > LIM1 + 68 ms |
| | (c) | | I. | in lead I or V5, R > LIM1 + 68 ms, and Q > -0.02 mV |
| | | or | II. | in lead I or V5, R' > LIM1 + 68 ms, and S > -0.02 mV |

7. Incomplete RBBB

| | | | | |
|---|---|---|---|---|
| | (a) | | I. | in V1 or V2, R' ⩾ 0.2 mV and, in the same lead, |
| | | | | R' -ST amplitude > 0.05mV and S' > 0.2 mV, and R' > R |
| | | and | II. | LIM1 + 68 ms < QRS duration < LIM1 + 88 ms. |
| and | (b) | | I. | there is no atrial fibrillation or flutter |
| | | or | II. | there is atrial fibrillation |
| | | | | or flutterand R' amplitude > 3*max (P+, P-) |
| and | (c) | | | Brugada pattern is not present |

8. rSr'(V1) - probable normal variant

Of the following criteria, either (a) or (b) is true and (c) and (d) are true

| | | | | |
|---|---|---|---|---|
| | (a) | | I. | 7(a)(i) is true. |
| | | and | II. | QRS duration < LIM1 + 68 ms. |
| or | (b) | | I. | In V1 or V2, 0.15mV < R' < 0.2mV and, in the same lead, |
| | | | | R'-ST amplitude > 0.05 mV and S' > 0.2 mV and R' > R |
| | | and | II. | QRS duration < LIM1 + 88 ms. |
| and | (c) | | I. | there is no atrial fibrillation or flutter |
| | | and | II. | there is atrial fibrillation |
| | | | | or flutterand R' amplitude > 3*max ( P+ , P-) |
| and | (d) | | | Brugada pattern is not present |

# 10 Wolff-Parkinson-White pattern

The diagnosis of WPW pattern is based on an algorithm developed by Fitzpatrick et al[1].

**Criteria**

| | | | | | |
|---|---|---|---|---|---|
| A. | | | | | QRS duration > 103 ms |
| B. | | | | | PR interval < 185ms |
| C. | | | | | The P axis value lies between -1° and 90° inclusive. |
| D. | | | | | Sum of delta wave confidences over all leads >= 100% |
| E. | 1. | (a) | | | There is a 65% confidence of a delta wave in any 2 of leads I, II, III, aVL, aVF, V1, V2, V3. V4, V5, V6. |
| | and | (b) | I. | | Sum of delta wave confidences over all leads >= 200% |
| | | or | II. | | PR interval < 160ms |
| or | 2. | (a) | | | PR interval < 115ms |
| | and | (b) | I. | | There is a 60% confidence of a delta wave in any 2 of leads I, II, III, aVL, aVF, V1, V2, V3. V4, V5, V6. |
| | | or | II. | | There is a 40% confidence of a delta wave in any 3 of leads I, II, III, aVL, aVF, V1, V2, V3. V4, V5, V6. |

WPW pattern is present if all criteria A,B,C,D,E are met.

The statements are of the form:

WPW pattern – probable * accessory pathway

where * is the location and can be one of the following

- right posteroseptal
- midseptal
- anteroseptal
- right anterolateral
- right posterolateral
- left anterolateral
- left posteroseptal
- left posterolateral

**Statements**

1. WPW pattern – probable right posteroseptal accessory pathway

| | | | | |
|---|---|---|---|---|
| | (a) | | I. | QRS transition between leads V1 and V2, or at V2and Ramp > (\|S amp\| + 1.0mV) in lead I |
| | | or | II. | QRS transition between lead V2 and V3, or at V3 |
| | | or | III. | QRS transition between leads V3 and V4 and delta wave II ⩾ 1.0 mV |
| and | (b) | | | Sum of delta wave polarities (II, III, aVF) ⩽ -2 |

[1] Fitzpatrick AP, Gonzales RP, Lesh MD, et al. New algorithm for the localization of accessory atrioventricular connections using a baseline electrocardiogram. J Am Coll Cardiol 1994;23:107-116.

2. WPW pattern – probable midseptal accessory pathway

(a) 1(a) is true

and (b) -2 < Sum of delta wave polarities (II, III, aVF) < 2

3. WPW pattern – probable anteroseptal accessory pathway

(a) 1(a) is true

and (b) Sum of delta wave polarities (II, III, aVF) ⩾ 2

4. WPW pattern – probable right anterolateral accessory pathway

(a) I. QRS transition between leads V3 and V4 and delta wave in lead II < 1.0 mV

or II. QRS transition at or after lead V4

and (b) I. If delta wave frontal axis ⩾ 1°

or II. R amp in lead III ⩾ 0

5. WPW pattern – probable right posterolateral accessory pathway

(a) 4(a) is true

and (b) 4(b) is false

6. WPW pattern – probable left anterolateral accessory pathway

(a) I. QRS transition before or at lead V1

or II. QRS transition between leads V1 and V2, or at V2and R amp ⩽ (|S amp| + 1.0mV) in lead I

and (b) I. Sum of delta wave polarities in (II, III, aVF) ⩾ 2

or II. R amp > |S amp| in aVL

7. WPW pattern – probable left posteroseptal accessory pathway

(a) 6(a) is true

and (b) 6(b) is false

and (b) I. Sum of delta wave polarities in (II, III, aVF) < 0

and II. R amp > (|S amp| + 0.8mV) in I

8. WPW pattern – probable left posterolateral accessory pathway

(a) 6(a) is true

and (b) 6(b) is false

and (c) 7(c) is false

# 11 Brugada pattern

The Brugada pattern statement is implemented according to the criteria published in the Second Consensus Conference on the Brugada Syndrome[1].

### Criteria

| | |
|---|---|
| A. | STj > 0.2mV |
| B. | R' amplitude > 0.2mV |
| C. | ST slope < -15° |
| D. | T- amplitude < -0.05mV |
| E. | T morphology is +2 |

### Statements

1. Marked ST elevation – consider Brugada pattern

| | | |
|---|---|---|
| | (a) | Atrial Flutter is not present |
| and | (b) | A and B and C and D and E are true in V1, V2 or V3 |

[1] Antzelevitch C, Brugada P, Borggrefe M, et al. Brugada Syndrome. Report of the Second Consensus Conference. Endorsed by the Heart Rhythm Society and the European Heart Rhythm Association. Circulation 2005;111:659-670.

# 12 Hypertrophy

## 12.1 Left ventricular hypertrophy

If WPW or LBBB has been detected, this section is omitted.

The criteria for LVH are in the form of points awarded for each test. The points are to talled to give a final score.

In a fashion similar to the use of a continuous equation for a normal limit of duration, it is feasible to use such an equation for upper limits of normal voltage of Q, R and S amplitudes. Such equations can be used for adults and children. An example is given for the upper limit of normal R wave amplitude in V5 for boys aged 11 to 18 years:

$$RV5 = [93.4 - 0.166 \text{ age (months)}]^2$$

A complete set of equations is too detailed to print. For adults, there are separate equations for males and females while for children the continuous equations are also at times sex dependent and, on occasions, are split into two with one equation being from birth to one month of age and the other being from one month until adolescence.

It is also worth noting that equations are dependent on race and at the present time, separate equations are available for Caucasian and Oriental adults.

corpuls3 does not support race as an input.

For clarity, the criteria describe discrete thresholds and integer scores. However, as in other parts of the program, the discrete thresholds have been replaced by smooth continuous functions which return continuous scores. These are combined, where required, with other criteria using algebraic rules and the resulting overall score is used to determine the diagnostic statement that is output.

**Criteria**

A. Amplitude (use only the maximum score from criteria I-V). Each part scores 2 points. In addition, Part I, scores 1 extra point for each 0.3mV over the limit. Parts II, III and V score 1 extra point for every 0.5mV over the limit for patients aged 17 and over. Also, 1 point is deducted from I-V if there are Q waves or low R waves in the anterior leads.

I. the largest R in I or aVL ⩾ an age and sex dependent limit

II. |S| in V1 or V2 ⩾ an age and sex dependent limit

III. R in V5 or V6 ⩾ an age and sex dependent limit

IV. the Lewis Index (RI + |S|III) - (RIII+ |S|I) > an age and sex dependent limit (for age 17 and over only)

V. the Sokolow Lyon Index |SV1| + RV5/V6 > an age and sex dependent limit (for age 17 years and over only)

Table of sex and age dependent limits for criterion A. All figures are in millivolts.

| | Birth | 17 years | | 50 years | |
|---|---|---|---|---|---|
| | | Male | Female | Male | Female |
| R in I | 1.3 | 1.5 | 1.5 | 1.6 | 1.4 |
| R in aVL | 0.9 | 1.1 | 0.9 | 1.3 | 1.2 |
| S in V1,V2 | 3.0 | 4.0 | 3.5 | 2.5 | 2.0 |
| R in V5, V6 | 3.25 | 4.0 | 2.5 | 2.5 | 2.2 |
| Lewis Index | - | 2.5 | 2.0 | 2.0 | 1.8 |
| Sokolow Lyon Index | - | 5.0 | 4.25 | 4.5 | 3.75 |

B. (1-4 points) (a) In any of I, aVL, V5 or V6

I. ST ⩽ -0.02mV and ST slope is downward sloping
ST ⩽ -0.05mV and ST slope is flat or downward sloping

II. ST - T - > 0.1mV

III. T- < -0.2mV with T+ < 0.15mV

IV. R or R' > 1.0mV

V. There are no pathological Q waves in the lateral leads

VI. QRS < 120ms.

Score 4 points if I-VI are true

Score 2 points if I,II, III, V, VI are true

(b) If (a) is not true then consider:

I. ST or T changes in the lateral leads

II. A (I or IV is true)

III. A (II, III or V) is true and not anterior infarction

IV. A (II, III or V) is true and anterior infarction

V. QRS < 120ms.

Score 2 points if I, V and (II or III)

Score 1 point if I, IV and V.

N.B. If B(a) or B(b) is true, deduct 2 points if there is inferior infarction with T- aVF < -0.05mV.

C. (2 points) I. In any of I, aVL, V5 or V6

and II. the terminal amplitude of P in V1 < -0.11mV

and III. the terminal duration of P in V1 ⩾ 40ms

If C is not true, score 1 if atrial fibrillation or atrial flutter is present.

D. (2 points) I. inferior infarction has not been detected

and II. age ⩾ 17 years

and III. -120° < frontal QRS axis < -30°

E. (1point)
- I. the QRS duration in lead V5 or V6 ⩾ 100ms
- II. RBBB of any type is not present

F. (1point)
- I. the intrinsicoid deflection in V5 or V6 ⩾ 60ms
- and II. there are no pathological Q waves (see Myocardial Infarction section) in the corresponding lead.

**Alternative Criteria**

G. (4-5 Points)
- I. age ⩾ 17 years
- and II. 90ms < the overall QRS duration < 120ms
- and III. he R or R' amplitude in aVL > 0.2mV
- and IV. the sum of max (R,R') amplitude in aVL and max (S,S') amplitude in V3 > 2.8mV

Score 4 points if I, II, III and IV are true.

Score 5 points if I, II, III and IV are true and II and IV exceed lower thresholds significantly.

Test G is an alternative to tests A to F if A-F did not result in diagnosis of LVH.

**Statements**

1. Left ventricular hypertrophy
   - (a) score ⩾ 5 points
2. Possible left ventricular hypertrophy
   - (a) 4 ⩽ score < 5 points and there are ST or T abnormalities in the lateral leads.
3. Left ventricular hypertrophy, possible digitalis effect
   - (a) 1(a) is true
   - and (b) patient is on digitalis
4. Possible left ventricular hypertrophy, possible digitalis effect
   - (a) 2 (a) is true
   - and (b) patient is on digitalis
5. Left ventricular hypertrophy by voltage only
   - I. LVH score ⩾ 4 points
   - and II. criteria B-F are falseor G is true
   - and III. there are no lateral ST-T changes

6. Borderline high QRS voltage – probable normal variant

This statement replaces 1 or 2, if the following are true:

I. the LVH score ⩽ 5 points
and II. G or any part of A above is true
and III. there is no BVH
and IV. the patient is less than 35 years old
and V. there are no ST-T changes
and VI. there are no ST-T reasons for LVH set

## 12.2 Right ventricular hypertrophy

If WPW has been detected, this section is omitted.

The criteria for RVH are in the form of points awarded for each test. The points are to talled to give a final score.

The upper limits of normal voltage used for R and S amplitudes in the diagnosis of right ventricular hypertrophy are age dependent and can be made available in the form of continuous equations. A complete set of equations is too complex to include but as an example, the upper limit of S wave amplitude in Lead I is presented. The equation is valid from birth to 30 days.

$$LIM1 = [40 - 0.267 \times Age(days)]^2 \ \mu V$$

The following table is a guide to the various limits used in this section. Adult criteria are obtained using the higher values while paediatric criteria are derived from an age dependent value intermediate to the two lower limits.

| | Birth | Adolescence | Age 60 years |
|---|---|---|---|
| LIM1 | 1.6 mV | 0.482 mV | 0.36 mV |
| LIM2 | 2.5 mV | 1.5 mV | |
| LIM3 | 3.14 mV | 0.78 mV | 0.56 mV |
| LIM4 | 2.17 mV | 1.6 mV | |
| LIM5 | 10.9 | 1.1 | |
| LIM6 | 204° | 90° | |

For clarity, the criteria describe discrete thresholds and integer scores. However, as in other parts of the program, the discrete thresholds have been replaced by smooth continuous functions which return continuous scores. These are combined, where required, with other criteria using algebraic rules and the resulting overall score is used to determine the diagnostic statement that is output.

**Criteria**

A. (2 points)
I. in Lead I, either S or S' > LIM1
and II. in Lead I, R > 0.1mV
and III. in Lead I, |S| > R or |S'| > R'

| | | | | |
|---|---|---|---|---|
| B. (3 points) | | | I. | in Lead I, either S or S' > 2.5*LIM1 with R > 0.1mV |
| | | or | II. | in V5, either S or S' > LIM2 |
| | | or | III. | Age < 18 years and in V5, 4*max (S,S') > max (R,R') where max (S,S') > 1.0 mV |

N.B. (if both A and B are true, count only B).

| | | | | |
|---|---|---|---|---|
| C. (2 points) | (a) | | I. | in lead V1, the R or R' amplitude > LIM3 |
| | | and | II. | T+ in V1 ⩽ 0.7mV (age 12-30 years), or 0.5mV (age ⩾ 30years) |
| | or (b) | | I. | In V4R, R > LIM4 |
| | | and | II. | T+ in V4R ⩽ 0.7mV |

D. (1 point) R' > 0.1mV and R' > R in lead V1 and age ⩾ 16 years

| | | | | |
|---|---|---|---|---|
| E. (2 points) | (a) | | I. | in V1, the R/\|S\| amplitude ratio LIM5 with S > 0.1mV |
| | | or | II. | in V1, Q and S = 0mV and age > 5 years |
| | and (b) | | | in V1, either R or R' > 0.4mV, |
| | and (c) | | | T+ amplitude in V1 ⩽ 0.5mV |

F. (3 points) in V1, \|Q\| > 0.1mV and Q ⩾ 25ms, and R ⩾ 0.25mV with R-STj ⩾ 0.04mV and S = 0mV

G. (1 point) in aVF, the P+ amplitude ⩾ 0.3mV

| | | | |
|---|---|---|---|
| H. (1 point) | | I. | in aVF, the ST junction is negative |
| | or | II. | in aVF, T- < -0.1mV, and the T wave morphology is not +2 |

| | | | | |
|---|---|---|---|---|
| J. (3 points) | (a) | | I. | in V2, STj < 0.02mV with downward slope < -5 |
| | | and | II. | in V2, T- < -0.1mV |
| | | and | III. | age ⩾ 5 years |
| | | and | IV. | in aVF, STj < 0.15mV |
| | or (b) | | I. | in V2, STj < -0.15 mV with downward slope < 0 |
| | | and | II. | in V2, T- < -0.1 mV |
| | | and | III. | age < 5 years |

K. (1 point) LIM6 < QRS axis < 270°

| | | | | |
|---|---|---|---|---|
| L. (1 point) | | | I. | in all the Leads I, II, and III, \|S\| > 0.2mV |
| | | or | II. | QRS axis > 0°. |
| M. (4 points) | (a) | | I. | age > 5 days and < 9 years |
| | | and | II. | In V1,V5 and V6, T+ > 0.1mV and T- = 0mV |
| | or (b) | | I. | age ⩽ 5 days |
| | | and | II. | In V1, T+ > 0.1mV and T- = 0mV |
| | | and | III. | there is left axis deviation |

**Statements**

1. Right ventricular hypertrophy

| | | |
|---|---|---|
| | (a) | Score ⩾ 5 points |

2. Possible right ventricular hypertrophy

| | | |
|---|---|---|
| | (a) | 4 ⩽ score < 5 points |

3. Right ventricular hypertrophy, possible digitalis effect

| | | |
|---|---|---|
| | (a) | 1(a) is true |
| and | (b) | patient is on digitalis |

4. Possible right ventricular hypertrophy, possible digitalis effect

| | | |
|---|---|---|
| | (a) | 2(a) is true |
| and | (b) | patient is on digitalis |

## 12.3 Biventricular hypertrophy

**Statements**

If LBBB or WPW is set true, omit this section.

1. Biventricular hypertrophy

| | | | | |
|---|---|---|---|---|
| | (a) | | I. | LV hypertrophy score ⩾ 5 points |
| | | and | II. | RV hypertrophy score ⩾ 5 points |
| or | (b) | | | the maximum QRS vector > an age dependent limit A (see table) |
| or | (c) | | I. | LV hypertrophy score ⩾ 11 points |
| | | and | II. | the maximum QRS vector (in I, aVF, V2) > age dependent limit B (see table). |

2. Possible biventricular hypertrophy

| | | | | |
|---|---|---|---|---|
| | (a) | | | statements 1 is not true |
| and | (b) | | I. | LV hypertrophy score ⩾ 4 points |
| | | and | II. | RV hypertrophy score ⩾ 4 points |

Table of age dependent limits for max QRS vector

| | Age < 30 years | 30 ⩽ Age < 40 years | Age ⩾ 40 years |
|---|---|---|---|
| LIMIT A | 6.0 mV | 5.0 mV | 4.5 mV |
| LIMIT B | 5.5 mV | 4.5 mV | 4.0 mV |

# 13 Myocardial infarction

In this section, there are three types of criteria used in the diagnosis of myocardial infarction.The first type uses criteria for acute ST elevation myocardial infarction (STEMI) in the absence of LBBB. The second uses Sgarbossa's criteria for an acute MI in the presence of LBBB and the third uses criteria based on Q waves and ST-T amplitudes.

STEMI criteria are modelled on the ACC/ESC criteria in the absence of LBBB and Sgarbossa's criteria in the presence of LBBB.

If Q waves are detected, then one of a number of statements may also be output, e.g.

*** INFERIOR INFARCT – POSSIBLY ACUTE ***

The criteria for these statements are given in detail in this chapter.

## 13.1 STEMI criteria

STEMI criteria were initially modelled on the recommendations[1] of the American College of Cardiology (ACC) and the European Society of Cardiology (ESC) in a consensus document entitled Myocardial Infarction Redefined. These criteria were based on increased ST elevation in two contiguous leads. Subsequent work in Glasgow[2,3] introduced age and sex dependent criteria. As a result, in 2007, sex dependent criteria were included in the first Universal Definition of myocardial infarction[4] and subsequently age and gender based criteria were included in the third universal definition of myocardial infarction in 2012. They remained in the fourth universal definition of 2019[5]. The new criteria use continuous equations for upper limits of normal ST amplitudes, measured at the J point as in the recommendations[1] as well as |ST/T| + |S/ST| ratios and |Q| + |S| amplitudes and have been extended to included racial differences among Black, Oriental and Caucasian individuals of both sexes[6].

The upper limits of normal ST amplitudes are determined from a set of equations. There is a different equation for each lead. As an example, the equation for lead V1 for male patients is given here.

| Age (years) | Limit in µV |
|---|---|
| 20 ⩽ age ⩽ 60 | (-1.0) * age ( in years) + 190 |
| > 60 | (-1) * 60 + 190 = 130 |
| < 20 | (-1) * 20 + 190 = 170 |

For female patients, a constant value is used as a limit across all ages. The constant is lead dependent. For V1, the limit is 100µV.

A second set of thresholds for ST amplitudes is used to determine which critical value statement (see section headed CRITICAL VALUES) is output when the STEMI criteria are met. If these (higher) limits are reached then the critical value statement ACUTE STEMI is reported. If the upper limits for normal ST amplitudes are exceeded, but not the higher limits, then the critical value statement POSSIBLEACUTE STEMI is reported.


1 Joint ESC/ACC Committee. Myocardial infarction redefined. European Heart J 2000; 21:1502-1513.

2 Macfarlane PW, et al. Modification of ACC/ESC criteria for acute myocardial infarction. J Electrocardiol 2004;37(Suppl):98-103.

3 Macfarlane PW, et al. Evaluation of age and sex dependent criteria for ST elevation myocardial Infarction. Computers in Cardiology 2007;34:293-296.

4 Thygesen K et al. Universal definition of myocardial infarction. Circulation 2007;116:2634-2653.

5 Thygesen K et al. Fourth universal definition of myocardial infarction (2018). European Heart Journal 2019;40:237–269

6 Macfarlane PW et al. Racial differences in the ECG – selected aspects. J Electrocardiol 2014;47:809-814.

The criteria for STEMI are omitted under the following conditions:

- presence of WPW
- presence of LBBB
- QRS duration > 180ms
- age ⩽ 18 years
- presence of IVCD and overall QRS duration > 140ms
  (except if very high ST values for leads where an individual lead QRS duration < 110ms)

**NSTEMI**

An acute myocardial infarction can be detected in the absence of ST elevation. The term non ST elevation myocardial infarction (NSTEMI) can be found in the joint ESC/ACC paper dealing with myocardial infarction redefined[1]. The criteria linked with NSTEMI in the program relate to marked ST depression which would be reflected in ST elevation in leads oppositely directed to those with ST depression but which may not be recorded. They can be found in this criteria handbook in the section on ST DEPRESSION.

## 13.2 Sgarbossa's criteria

If LBBB is present, then the criteria for acute MI as given by Sgarbossa et al[2] are used.

The criteria are as follows:

- ST segment elevation > 1mm that is concordant with the QRS complex (score 5)
- ST segment depression > 1mm in leads V1, V2 or V3 (score 3)
- ST segment elevation > 5 mm that is discordant with the QRS complex (score 2)

The ST amplitude is measured at the J point as per the original publication[1]. According to Sgarbossa et al, any score > 3 implies an acute MI. The higher the score, the greater the likelihood of an acute MI.

These criteria are omitted under the following conditions:

- presence of WPW
- presence of Brugada pattern
- QRS duration > 180ms
- Heart Rate > 150bpm

## 13.3 Q wave criteria

Omit this section if WPW is present.

Omit leads V2-V4 if LBBB is present.

Statements mentioning myocardial infarction are not output in the paediatric age group, in which criteria for abnormal Q waves are checked and if any are found to be true, the statement " Abnormal Q waves " is produced.

It should also be noted that neural network software is used in addition to the criteria listed overleaf.

A neural network utilising 9 input measurements, namely, the Q amplitude and duration as well as the Q/R ratio in Leads II, III and aVF has been trained to check for the presence of inferior myocardial infarction. However, the output from the network is not used in isolation. It is combined with the diagnosis made by the deterministic criteria listed in the following pages.

1 Joint ESC/ACC Committee. Myocardial infarction redefined. European Heart J 2000; 21:1502-1513.

2 Sgarbossa EB, Pinski SL, Barbagelata A, et al. Electrocardiographic diagnosis ofevolving acute myocardial infarction in the presence of left bundle branch block. NEngl J Med 1996;334:481–7

If the neural network detects inferior infarction, it is given a level of PROBABLE infarction. The level of certainty of the deterministic criteria is then compared with the neural network level and whichever is the higher is retained in the diagnosis. In addition, however, a neural network diagnosis of inferior infarction in the absence of deterministic criteria for infarction results in further checks being made to ensure that a Q wave is indeed present in aVF. This is to ensure that maximum specificity is obtained.

In the case of anterior myocardial infarction, a similar hybrid approach has been adopted. In this case, however, the network has 42 inputs. There are six measurements from each of 7 leads, namely, I, aVL, and V2-V6. These six measurements consist of the Q amplitude and duration, the R wave amplitude, the ST amplitude and the maximum positive and minimum negative T wave amplitudes. However, if the standard criteria listed for the different forms of anterior infarction, e.g. anteroseptal, anterior and septal, are already positive, then the neural network is not utilised. If conventional criteria are negative, then the neural network diagnosis is used. In this case, a check has to be made to see whether there are indeed Q waves or whether there are low R waves so that the appropriate reason statement can be produced.

For clarity, the criteria describe discrete thresholds and integer scores. However, as in other parts of the program, the discrete thresholds have been replaced by smooth continuous functions which return continuous scores. These are combined, where required, with other criteria using algebraic rules and the resulting overall score is used to determine the diagnostic statement that is output.

### 13.3.1 Q waves in inferior and lateral leads

**Criteria**

| | | | | |
|---|---|---|---|---|
| Q1 | (a) | | I. | Q > 35ms and \|Q/R\| > 1/5 |
| | | or | II. | Q > 40ms |
| | | or | III. | T axis < 0°, and Q > 28ms, and \|Q/R\| > 1/4 in aVF |
| and | (b) | | | \|Q\| > 0.09mV |
| and | (c) | | | peak to peak QRS > 0.15mV |
| Q2 | (a) | | I. | Q > 35ms and \|Q/R\| > 1/5 |
| | | or | II. | Q > 30ms and \|Q/R\| > 1/3 |
| and | (b) | | | \|Q\| > 0.2mV |
| and | (c) | | | peak to peak QRS > 0.15mV |
| Q3 | (a) | | | Q > 26ms or \|Q/R\| > 1/5 |
| and | (b) | | | \|Q\| > 0.11mV |
| and | (c) | | | peak to peak QRS > 0.15mV |
| Q4 | (a) | | I. | Q ⩾ 30ms and T- < -0.1mV |
| | | or | II. | \|Q/R\| > 1/3 and Q > 0.02secs |
| and | (b) | | | \|Q\| > 0.075mV |
| and | (c) | | | peak to peak QRS > 0.2mV |
| and | (d) | | I. | T- < -0.05mV |
| | | or | II. | ST > 0.06mV |
| Q5 | (a) | | | \|Q/R\| > 1/4 in II and \|Q\| > 0.1mV |
| and | (b) | | | QRS axis < 0° |
| and | (c) | | | Age > 18 years |

| | | | | |
|---|---|---|---|---|
| Q6 | (a) | | I. | R amplitude in II < R amplitude in III |
| | | or | II. | QRS axis ⩽ -30° |
| | | or | III. | R < 0.20mV in III. |
| | | or | IV. | Age > 18 years |
| or | (b) | | I. | Q ⩾ 15ms and R < 0.1mV and S > 20ms in aVF |
| | | and | II. | peak-peak QRS > 0.15mV in aVF |
| | | and | III. | Age > 18 years |
| Q7 | (a) | | | T axis < -10° |
| and | (b) | | | R < 0.90mV in II |
| and | (c) | | | \|Q/R\| > 1/5 and \|Q\| > 0.05mV in any 2 of II, III, or aVF |
| and | (d) | | | Rhythm is not atrial flutter |
| and | (e) | | | Age > 18 years |

Similar criteria apply when a small primary r is present. In this case, S replaces Q and R' replaces R.

### Inferior infarction statements

The tests for Q1 to Q4 are caried out on II, III, aVF. The following statements therefore refer to findings in these leads.

1. *** INFERIOR INFARCT – POSSIBLY ACUTE ***

| | | | | |
|---|---|---|---|---|
| | A. | Presence of Q waves | | |
| | | (a) | I. | there are two or more Q1 |
| | | or | II. | there is at least one Q1 and one Q2 |
| | or | (b) | I. | there is one Q1 and at least one Q3 or Q4 |
| | | or | II. | there are two or more Q2 |
| | | or | III. | there is one Q2 and one Q3 |
| | | or | IV. | there is one Q1 from II or aVF |
| | | or | V. | there is one Q5 |
| | | or | VI. | there is one Q2 and one Q4 |
| | | or | VII. | there are two or more Q3 with \|Q/R\| > 1/4 |
| | | or | VIII. | there is one Q6 or one Q7 |
| and | B. | Acute ST elevation MI suspected | | |
| | | (a) | | the STEMI criteria are met. |
| and | C. | (a) | | LBBB is not present |

2. Inferior infarct – age undetermined

| | | | |
|---|---|---|---|
| | (a) | | 1 A(a) is true |
| and | (b) | | STEMI criteria are not met |
| and | (c) | | LBBB is not present |

3. Possible inferior infarct – age undetermined

| | | |
|---|---|---|
| | (a) | 1 A(a) or 1A(b) is true |
| and | (b) | LBBB is present |

4. Small inferior Q waves : infarct cannot be excluded

| | | | |
|---|---|---|---|
| | (a) | | 1 A(a) is false and 1A(b) is true |
| and | (b) | | STEMI criteria are not met |
| and | (c) | | LBBB is not present |
| and | (d) | | In lead III or avF, there is a Q wave ⩾ 0.02 secs, |
| | | | or an S wave ⩾ 0.02 secs where R wave < 0.04mV |

5. Small inferior Q waves noted: probably normal ECG

| | | | | |
|---|---|---|---|---|
| | (a) | | | 4 is true |
| and | (b) | | I. | there are no other diagnostic statements |
| | | or | II. | there is only one other diagnostic statement: |
| | | | | Small lateral Q waves noted: probably normal ECG |
| and | (c) | | | there is no T wave inversion in the inferior leads |
| and | (d) | | | T axis > 5° |
| and | (e) | | I. | in aVF, Q/R amplitude ratio < 0.5 andthere is an R wave in aVF |
| | | or | II. | in aVF, S/R' amplitude ratio < 0.5 andthe R wave in aVF < 0.05mV andthere is an R' wave in aVF. |
| and | (f) | | | the rhythm is sinus |

This statement replaces statement 4, if true.

6. Abnormal Q waves of undetermined cause

| | | |
|---|---|---|
| | (a) | if any of the previous statements is true |
| and | (b) | the age of the patient is less than 18 years |

Replace the previous statement by this one, if true.

7. Inferior Q waves may be due to cardiomyopathy

| | | | |
|---|---|---|---|
| | (a) | | any of the statements 2, 4 or 5 is true |
| and | (b) | | the age of the patient is between 18 and 40 years |
| and | (c) | I. | there is a Q wave but no R or S waves in leads II or aVF |
| | or | II. | there are Q equivalent waves and small R waves in II or aVF |
| and | (d) | | there is no T wave inversion in leads II or aVF |

Replace statement 2, 4 or 5 by this one, if true.

### Inferior infarction statement addition

8. Q waves may be due to cardiomyopathy

| | | |
|---|---|---|
| | (a) | if any of statements 1-6 is set |
| and | (b) | there is a clinical classification of cardiomyopathy |
| and | (c) | there is no T wave inversion in II or aVF |

### Lateral infarction statements

The tests for Q1 to Q4 are carried out on I, aVL, V5, V6.

The following statements therefore refer to findings in these leads.

1. *** LATERAL INFARCT – POSSIBLY ACUTE ***

A. Presence of Q waves

(a) I. there are two or more Q1

or II. there is one Q1 and at least one Q2

or (b) I. there is one Q1 and at least one Q3 or Q4

or II. there are two or more Q2

or III. there is one Q2 and one Q3

or IV. there is one Q2 and one Q4

or V. there are two or more Q3 with |Q/R| > 1/4

or VI. there is one or more Q1 from I, V5 or V6

and B. Acute ST elevation MI suspected

(a) the STEMI criteria are met.

2. Lateral infarction – age undetermined

(a) 1 A(a) is true

and (b) STEMI criteria are not met

3. Possible lateral infarction – age undetermined

(a) 1 A(a) is false and 1 A(b) is true

and (b) STEMI criteria are not met

4. Small lateral Q waves noted: probably normal ECG

(a) 3 is true

and (b) I. there are no other diagnostic statements

or II. there is only one other diagnostic statement:
Small inferior Q waves noted: probably normal ECG

and (c) there is no T wave inversion in the lateral leads

and (d) T axis < 85°

and (e) I. in I, there is a Q wave ⩾ 0.02 secs and an R wave in I
and the Q/R amplitude ratio < 0.5

or II. in I, there is an S wave ⩾ 0.02 secs and the R wave < 0.04 mV
and the S/R' amplitude ratio < 0.5

and (f) the rhythm is sinus

This statement replaces statement 3, if true.

5. Abnormal Q waves of undetermined cause

(a) if any of the previous statements is true

and (b) the age of the patient is less than 18 years

Replace the previous statement by this one, if true.

6. Lateral Q waves may be due to cardiomyopathy

| | | |
|---|---|---|
| | (a) | any of the statements 2, 3 or 4 is true |
| and | (b) | the age of the patient is between 18 and 40 years |
| and | (c) | there is a Q wave but no R or S waves in lead I |
| and | (d) | there is no T wave inversion in lead I |

Replace statement 2, 3 or 4 by this one, if true.

**Lateral infarction statement addition**

7. Q waves may be due to cardiomyopathy

| | | |
|---|---|---|
| | (a) | if any of statements 1-5 is set |
| and | (b) | there is a clinical classification of cardiomyopathy |
| and | (d) | there is no T wave inversion in the lateral leads |

### 13.3.2 Q waves in anteroseptal, anterior or septal leads

**Criteria**

| | | | | |
|---|---|---|---|---|
| VQ1 | (a) | | I. | \|Q\| > 0.2mV or \|Q\| > 0.15mV and \|Q/R\| > 1/2 |
| | | and | II. | Q > 30ms |
| | | and | III. | peak to peak amplitude > 0.2mV |
| or | (b) | | I. | R = 0 |
| | | and | II. | \|S\| > 0.2mV |
| | | and | III. | S > 30ms |
| | | and | IV. | peak to peak amplitude > 0.2mV |
| VQ2 | (a) | | I. | Q\| > 0.14mV |
| | | and | II. | Q > 20ms |
| | | and | III. | \|Q/R\| > 1/5 |
| | | and | IV. | peak to peak amplitude > 0.2mV |
| or | (b) | | I. | R < 0.065mV |
| | | and | II. | \|S\| > 0.14mV |
| | | and | III. | S > 20ms |
| | | and | IV. | \|S/R'\| > 1/5 |
| VQ3 | (a) | | I. | R < 0.11mV |
| | | and | II. | R' < 2R amplitude, or RBBB is present |
| | | and | III. | \|R/S\| < 0.125 |
| | | and | IV. | the peak to peak amplitude > 0.2mV |
| | | and | V. | RVH is not present |
| VQ4 | (a) | | I. | R in V(n) - R in V(n+1) > 0.05mV<br>in the adjacentprecordial ead, (e.g. V3 < V2) |
| | | and | II. | R < 0.3mV in those two leads |
| | | and | III. | R' < R in those two leads |

| | | | | |
|---|---|---|---|---|
| QRVH | (a) | | I. | R > 0.3mV with S = 0mV or R < 0.1mV with R' > 0.3mV |
| | | and | II. | RBBB and IVCD are not present |
| | | and | III. | ST in V2 ⩽ 0.12mV or ST < 1/2 T+ |
| | or (b) | | I. | R < 0.3mV or S is not 0mV |
| | | and | II. | in Lead I, S or S' < -0.5mV |
| | | and | III. | there is a clinical classification of congenital heart disease, rheumatic heart disease, pericarditis, respiratory disease, implanted pacemaker, pulmonary embolism, post-operative changes, cardiomyopathy or other/not known |
| | | and | IV. | RBBB and IVCD are not present |
| PRWP | (a) | | I. | Male and R V3 < 0.3mV and R' V3 < 0.3mV |
| | | or | II. | Female and R V3 < 0.25mV and R' V3 < 0.25mV |
| | and (b) | | | None of VQ1-VQ4 is true |

**Anteroseptal infarction statements**

The tests for VQ1 - VQ4 are applied to V2 - V4.

The following statements therefore apply to findings in these leads.

1. *** ANTEROSEPTAL INFARCT – POSSIBLY ACUTE ***

| | | | | |
|---|---|---|---|---|
| | A. | Presence of Q waves | | |
| | | (a) | | VQ1 is true for V2 and one of V3, V4 with QRVH false in V1 |
| | or | (b) | I. | one VQ1 is true, and there is a VQ in V2 and in V3 or V4 with QRVH false in V1 |
| | | | or II. | VQ2(a) is true in V2 and one of V3, V4 with QRVH false inV1 |
| | | | or III. | VQ2(b) is true in V2 and one of V3, V4 |
| and | B. | Acute ST elevation MI suspected | | |
| | | (a) | | the STEMI criteria are met. |

2. Anteroseptal infarct – age undetermined

| | | |
|---|---|---|
| | (a) | 1 A(a) is true |
| and | (b) | STEMI criteria are not met |

3. Possible anteroseptal infarct – age undetermined

| | | |
|---|---|---|
| | (a) | 1 A(a) is false and 1 A(b) is true |
| and | (b) | STEMI criteria are not met |

4. Cannot rule out anteroseptal infarct – age undetermined

| | | |
|---|---|---|
| | (a) | if any of the statements 1-3 is set true |
| and | (b) | LVH is present |
| and | (c) | ST < 1/2 T+ in V2 and V3 |
| and | (d) | there is not a clinical classification of either congenital heart disease or of rheumatic heart disease |
| and | (e) | the age of the patient is 18 years or over |
| and | (f) | VQ1 is false in both V3 and V4 |
| and | (g) | there is not clockwise cardiac rotation |

The above statement replaces any of 1-3, if true

5. Abnormal Q waves of undetermined cause

| | | |
|---|---|---|
| | (a) | any of the above statements is true, |
| and | (b) | the age of the patient is less than 18 years |

The above statement replaces any of 1-4, if true.

6. Anteroseptal QRS changes may be due to ventricular hypertrophy

| | | |
|---|---|---|
| | (a) | any of the above statements is true |
| and | (b) | there is moderate or high T+ in V2-V4 |
| and | (c) | ST < 1/2 T + in V2, V3 |
| and | (d) | there is not a clinical classification of myocardial infarction but there is of rheumatic heart disease |

The above statement replaces any previous one, if true.

7. Anteroseptal QRS changes may be due to corrected transposition

| | | |
|---|---|---|
| | (a) | if any of the above statements is true |
| and | (b) | there is moderate or high T+ in V2-V4 |
| and | (c) | ST < 1/2 T+ in V2 and V3 |
| and | (d) | there is not a clinical classification of myocardial infarction but there is a classification of congenital heart disease |

The above statement replaces any previous one, if true.

8. QRS changes may be due to LVH but cannot rule out anteroseptal infarct

| | | |
|---|---|---|
| | (a) | if any of the statements 1-4 is set true |
| and | (b) | LVH is present with secondary ST-T changes and \|S\| in V2 > 0.2mV |
| and | (c) | ST < 1/2 T+ in V2 and V3, |
| and | (d) | there is not a clinical classification of either congenital heart disease or of rheumatic heart disease |
| and | (e) | the age of the patient is 18 years or over |
| and | (f) | there is not clockwise cardiac rotation and VQ1 is false in V4 |

The above statement replaces any of 1-4, if true.

9. Poor R wave progression – cannot rule out anteroseptal infarct

(a) if any of the statements 1-4 is set true

and (b) ST < 1/2 T+ in V2 and V3

and (c) clockwise cardiac rotation is true, and VQ1 false in V4

The above statement replaces any of 1-4, if true.

10. Poor R wave progression consistent with pulmonary disease

(a) 9(a) to (c) are true

and (b) there is a clinical classification of respiratory disease but not of myocardial infarction

The above statement replaces 1-4, if true.

### Anteroseptal infarction statement addition

11. Q waves may be due to cardiomyopathy

(a) any of the anteroseptal infarction statements is set

and (b) there is a clinical classification of cardiomyopathy

and (c) there is moderate or high T+ in V2-V4

### Anterior myocardial infarction statements

The tests for VQ1-VQ4 are applied to V3, V4. The following statements therefore apply to findings in these leads.

1. *** ANTERIOR INFARCT – POSSIBLY ACUTE ***

A. Presence of Q waves

(a) VQ1 is true for V3 and V4 with QRVH false in V1

or (b) I. VQ1 is true for V3 or V4 with QRVH false in V1

or II. VQ4 is true for V2, V3 and V3, V4

or III. VQ2(a) is true in V3 or V4 with QRVH false in V1

or IV. VQ2(b) is true in V3 or V4 or VQ3 is true in V3 or V4 (except for females with T+ > 0.05mV in V3 and T morphology = 1 in V3, where there is not a clinical classification of myocardial infarction)

or V. VQ4 is true for V2, V3 or V3, V4 for males or for V4, V5 for males or females

or VI. PRWP is true and R < 0.4mV in I and not RVH and (|S| < 0.15mV in I or R > 0.4mV in V4 or T+ < 0.05mV in V2-V4)

or VII. PRWP is true and R ⩾ 0.4mV in I and [(ST > 0.05mV and ST > T+/2 in V3 or V4) or (LVH is present and R < 0.15mV in V4)]

and B. Acute ST elevation MI suspected

(a) the STEMI criteria are met.

2. Anterior infarct – age undetermined

(a) 1 A(a) is true

and (b) STEMI criteria are not met

3. Possible anterior infarct – age undetermined

| | | | |
|---|---|---|---|
| | A. | (a) | 1 A(a) is false and 1 A(b) is true |
| | and | (b) | STEMI criteria are not met |
| or | B. | (a) | if statement 1or 2 is true |
| | and | (b) | ST < 1/2 T+ in V3 and V4 |
| | and | (c) | clockwise cardiac rotation is true, and VQ1 false in V4 |

If 3B is true, statement 3 replaces statement 1 or 2.

4. Cannot rule out anterior infarct – age undetermined

| | | |
|---|---|---|
| | (a) | if any of the statements 1-3 is set true |
| and | (b) | LVH is present |
| and | (c) | ST < 1/2 T+ in V3 and V4 |
| and | (d) | there is not a clinical classification of either congenital heart disease or of rheumatic heart disease |
| and | (e) | the age of the patient is 18 years or over |
| and | (f) | VQ1 is false in both V3 and V4 |
| and | (g) | there is not clockwise cardiac rotation |
| and | (h) | VQ2 or VQ4 is true for V3 |

The above statement replaces any of 1-3, if true.

5. Abnormal Q waves of undetermined cause

| | | |
|---|---|---|
| | (a) | any of the above statements is true, |
| and | (b) | the age of the patient is less than 18 years |

The above statement replaces any of 1-4, if true.

6. Anterior QRS changes may be due to ventricular hypertrophy

| | | |
|---|---|---|
| | (a) | any of the above statements is true |
| and | (b) | there is moderate or high T + in V3, V4 |
| and | (c) | ST < 1/2 T + in V3 and V4 |
| and | (d) | there is not a clinical classification of myocardial infarction but there is of rheumatic heart disease. |

The above statement replaces any previous one, if true.

7. Anterior QRS changes may be due to corrected transposition

| | | |
|---|---|---|
| | (a) | if any of the above statements is true |
| and | (b) | there is moderate or high T+ in V3, V4 |
| and | (c) | ST < 1/2 T+ in V3, V4 |
| and | (d) | there is not a clinical classification of myocardial infarction but there is of congenital heart disease |

The above statement replaces any previous one, if true.

8. QRS changes V3/V4 may be due to LVH but cannot rule out anterior infarct

| | | |
|---|---|---|
| | (a) | if any of the statements 1-4 is set true or VQ3 is true |
| and | (b) | LVH is present with secondary ST-T changes and \|S\| in V2 > 0.2mV |
| and | (c) | ST < 1/2 T+ in V3 and V4 |
| and | (d) | there is not a clinical classification of either congenital heart disease or of rheumatic heart disease |
| and | (e) | the age of the patient is 18 years or over |
| and | (f) | there is not clockwise cardiac rotation, and VQ1 is false in V3 and V4 |

The above statement replaces any of 1-4, if true.

9. Anterior QRS changes are probably related to pulmonary disease

| | | |
|---|---|---|
| | (a) | 7(a) to (c) are true |
| and | (b) | there is a clinical classification of respiratory disease but not of myocardial infarction |

The above statement replaces 1-4, if true.

10. Poor R wave progression

| | | | | |
|---|---|---|---|---|
| | (a) | | I. | VQ3 or VQ4 or PRWP is true |
| | | and | II. | R or R' in I > 0.4mV |
| | | and | III. | there is moderate or high T+ in V2-V4 |
| | | and | IV. | there is no significant ST elevation V2-V4 |
| | | and | V. | 0.25mV < R ⩽ 0.4mV in V4 for males or 0.25mV < R ⩽ 0.3mV in V4 for females |
| | | and | VI. | there is no LVH |
| | | and | VII. | there is no inferior or lateral infarction |
| or | (b) | | I. | VQ3 or VQ4 or PRWP is true |
| | | and | II. | R or R' in I > 0.4mV and R or R' in V4 < 0.25mV |
| | | and | III. | there is no T inversion in V2-V4 |
| | | and | IV. | there is no significant ST elevation V2-V4 |
| | | and | V. | there is no LVH |
| | | and | VI. | there is no inferior or lateral infarction |

### Anterior infarction statements addition

1. Q waves may be due to cardiomyopathy

| | | |
|---|---|---|
| | (a) | any of the anterior infarction statements is set |
| and | (b) | there is a clinical classification of cardiomyopathy |
| and | (c) | there is moderate or high T+ in V3, V4 |

**Septal infarction statements**

1. *** SEPTAL INFARCT – POSSIBLY ACUTE ***

| | | | | |
|---|---|---|---|---|
| | A. | Presence of Q waves | | |
| | | (a) | | VQ1 is true for V2 with QRVH false in V1 |
| | or | (b) | | There is VQ2a in V2 with QRVH false in V1 |
| and | B. | Acute ST elevation MI suspected | | |
| | | (a) | | the STEMI criteria are met. |

2. Cannot rule out septal infarct – age undetermined

| | | | | |
|---|---|---|---|---|
| | A. | (a) | | 1 A(a) or (b) is true |
| | and | (b) | | LVH is present |
| | and | (c) | | ST < 1/2 T+ in V2 and there is not an age undetermined infarct |
| | and | (d) | | there is not a clinical classification of either congenital heart disease or of rheumatic heart disease |
| | and | (e) | | the age of the patient is 18 years or over |
| or | B. | (a) | | 1 A(a) or (b) is true |
| | and | (b) | | STEMI criteria are not met |
| | and | (c) | I. | RBBB or RVH is present |
| | | or | II. | LVH with repolarisation is not present and there is T inversion in V2 |

The above statement replaces 1, if true.

3. Q in V1/V2 may be normal variant but septal infarct cannot be excluded

| | | |
|---|---|---|
| | (a) | 1 A(a) or (b) is true |
| and | (b) | STEMI criteria are not met |
| and | (c) | RBBB, RVH and LVH are not present |
| and | (d) | the R and R' amplitude in V3 ⩽ 0.3mV |
| and | (e) | there is no T inversion in V2 |

4. Q in V1/V2 may be due to lead placement error though septal infarct cannot be excluded

| | | |
|---|---|---|
| | (a) | 1 A(a) or (b) is true |
| and | (b) | STEMI criteria are not met |
| and | (c) | RBBB, RVH and LVH are not present |
| and | (d) | R or R' amplitude in V3 > 0.3mV |
| and | (e) | there is no T inversion in V2 |

5. Q in V1/V2 may be due to LVH though septal infarct cannot be excluded

| | | |
|---|---|---|
| | (a) | 1 A(a) or (b) is true |
| and | (b) | 2 is false |
| and | (c) | STEMI criteria are not met |
| and | (d) | LVH with repolarisation is present |
| and | (e) | RBBB and RVH are not present |

6. Abnormal Q waves of undetermined cause

(a) any of the above statements is true,

and (b) the age of the patient is less than 18 years

The above statement replaces any of 1-5, if true.

7. Septal QRS changes may be due to ventricular hypertrophy

(a) any of the above statements 2-5 is true

and (b) there is no T- in V2

and (c) ST < 1/2 T+ in V2 and there is not an age undetermined infarct

and (d) there is not a clinical classification of myocardial infarction but there is of rheumatic heart disease

The above statement replaces statements 2-5, if true.

8. Septal QRS changes may be due to corrected transposition

(a) if any of the statements 2-5 is set true

and (a) if any of the above statements 2-5 is true

and (b) there is no T- in V2

and (c) ST < 1/2 T+ in V2 and there is not an age undetermined infarct

and (d) there is not a clinical classification of myocardial infarction but there is of congenital heart disease

The above statement replaces statements 2-5, if true.

9. QRS changes in V2 probably due to LVH but cannot rule out septal infarct

(a) if any of the statements 2-5 is set true

and (b) LVH is present and |Q| in V2 > 2.0mV

and (c) ST < 1/2 T+ in V2

and (d) there is not a clinical classification of either congenital heart disease or of rheumatic heart disease

and (e) the age of the patient is 18 years or over

The above statement replaces statements 2-5, if true.

10. Poor R wave progression – cannot rule out septal infarct

(a) if any of the statements 2-5 is set true

and (b) ST < 1/2 T+ in V3 and V4

and (c) clockwise cardiac rotation is true, and VQ1 false in V4

and (d) the age of the patient is 18 years or over

The above statement replaces any of 2-5, if true.

11. Poor R wave progression may be due to pulmonary disease

(a) 10(a) to (c) are true

and (b) there is a clinical classification of respiratory disease but not of myocardial infarction

and (c) the age of the patient is 18 years or over

The above statement replaces 2-5, if true.

**Septal infarction statement addition**

1. Q waves may be due to cardiomyopathy

| | | | |
|---|---|---|---|
| | (a) | | any of the septal infarction statements is set |
| and | (b) | | there is a clinical classification of cardiomyopathy |
| and | (c) | | there is moderate or high T+ in V2 |

## 13.4 Posterior myocardial infarction

**Criteria**

| | | | | |
|---|---|---|---|---|
| PMI1 | (a) | | I. | R in V1 > 40ms |
| | | and | II. | R in V1 > 0.8mV |
| | | and | III. | T+ in V1 > 0.5mV |
| | and (b) | | I. | R in V2 > 40ms |
| | | and | II. | R in V2 > 1mV |
| | | and | III. | T+ in V2 > 0.8mV |

**Posterior infarction statements**

If there are inferior or lateral infarct statements or RBBB or RVH, omit Statement 1.

1. Possible posterior infarct – age undetermined

| | | |
|---|---|---|
| | (a) | PMI1 is true |

**Posterior infarction statement additions**

2 and 3 are additions to any inferior or lateral infarction statement only.

2. Possible posterior extension of infarct

| | | |
|---|---|---|
| | (a) | PMI1 is set true |
| and | (b) | there is inferior or lateral myocardial infarction |

3. Tall R V1/V2 probably reflect the infarct

| | | |
|---|---|---|
| | (a) | RVH is true, with tall R in V1 or V2 |
| and | (b) | there is inferior or lateral myocardial infarction |
| and | (c) | RBBB is not present |

If 3 is true, then RVH is set false.

## 13.5 Anterolateral myocardial infarction

This section is entered if the following criteria are met.

| | | | | |
|---|---|---|---|---|
| | (a) | | I. | there is a Q1 in V5 |
| | | or | II. | there is a Q2 in V5 with lateral myocardial infarction true |
| and | (b) | | I. | there is a VQ1 or VQ2 in V4 |
| | | or | II. | there is a VQ3 in V4 or VQ4 in V3, V4 |

Any anterolateral statement will suppress the separate lateral, anteroseptal, and anterior statements.

1. *** ANTEROLATERAL INFARCT – POSSIBLY ACUTE ***

A. Presence of Q waves

(a) I. in I, aVL, V5, V6 there are two or more Q1 or at least one Q1 and Q2

or II. VQ1 is true for [V2 and (V3 or V4)] or (V3 and V4) with QRVH false for V1

or (b) I. in I, aVL, V5, V6 there is one Q1 and at least one Q3 or Q4

or II. in I, aVL, V5, V6 there are two or more Q2

or III. in I, aVL, V5, V6 there is one Q2 and one Q3

or IV. one VQ1 is true, and there is a VQ in V2 and in V3 or V4 with QRVH false in V1

or V. VQ1 is true for V3 or V4 with QRVH false in V1

or VI. VQ4 is true for V2, V3 or V3, V4

and B. Acute ST elevation MI suspected

(a) the STEMI criteria are met.

2. Anterolateral infarct – age undetermined

(a) 1 A(a) is true

and (b) STEMI criteria are not met

3. Possible anterolateral infarct – age undetermined

(a) 1 A(a) is false and 1 A(b) is true

and (b) STEMI criteria are not met

4. Abnormal Q waves of undetermined cause

(a) if any of the previous statements is set true

and (b) the age of the patient is less than 18 years

**Anterolateral infarction statement addition**

1. Q waves may be due to cardiomyopathy

(a) any of the anterolateral infarction statements is set

and (b) there is a clinical classification of cardiomyopathy

and (c) there is moderate or high T+ in anterolateral leads

## 13.6 Extensive myocardial infarction

This section is entered if the following criteria are met.

(a) there is inferior infarction
and (b) there is lateral infarction
and (c) there is anterior or anteroseptal infarction

1. *** EXTENSIVE INFARCT – POSSIBLY ACUTE ***

(a) I. there is inferior or lateral infarction
and II. there is anteroseptal infarction
and (b) the STEMI criteria are met.

2. Extensive infarct – age undetermined

(a) I. there is inferior or lateral infarction
and II. there is anteroseptal infarction
and (b) the STEMI criteria are not met

3. Possible extensive infarct – age undetermined

(a) weaker Q wave criteria are met in the inferior and anteroseptal leads
and (b) the STEMI criteria are not met

4. Abnormal Q waves of undetermined cause

(a) if any of the previous statements is set true
and (b) the age of the patient is less than 18 years

The above statement replaces any of 1-3, if true.

**Extensive infarction statement addition**

1. Q waves may be due to cardiomyopathy

(a) any of the extensive infarction statements is set
and (b) there is a clinical classification of cardiomyopathy
and (c) T waves are not inverted.

# 14 ST abnormalities

There are 3 sets of criteria used to determine the presence of ST abnormalities. The first uses the criteria for acute ST elevation as used to indicate myocardial infarction (STEMI). This is described in the chapter MYOCARDIAL INFARCTION. The second set of criteria is used to determine if the early repolarisation pattern of end QRS notching or slurring is present. The third criterion uses a scoring system for the ST elevation and depression in each lead. This scoring system uses the limits of normal ST amplitudes and the slope of the ST segment to determine a score varying from −3.0 to 3.0. For ST elevation in adult ECGs, the limits used are the same as in the STEMI criteria and are dependent on age, gender and lead. For paediatric ECGs and ST depression, the limits used are dependent on the age of the patient and on the wall i.e. inferior, lateral or anterior. The score gives an indication of the degree of elevation or depression and is based on a smoothed function using multiple variables.

Using these criteria, there are 4 categories of ST elevation used to determine which statement is output. These are the STEMI elevation, end QRS notching or slurring, marked ST elevation and moderate ST elevation.

End QRS notching/slurring is defined as follows: In the absence of LBBB, RBBB, Brugada pattern, a clinical classification of myocardial infarction and a clinical classification of pericarditis, end QRS notching/slurring is defined as:

| | | | |
|---|---|---|---|
| 1. | (a) | | The last component of the QRS complex is an R wave |
| and | (b) | | The R wave duration > 40msecs |
| and | (c) | | There is a notch or slur on the downward slope of the R wave |
| and | (d) | | The notch or slur has a minimum allowed amplitude of 0.1mV and a maximum of 0.5mV |

Marked and moderate elevation are defined as follows:

In the absence of LBBB, RBBB, Brugada pattern or any Q wave myocardial infarction,

Marked ST elevation is defined as:

| | | | | | |
|---|---|---|---|---|---|
| | 1. | (a) | | | a high score for ST elevation in 2 or more of leads I, II, III, aVL, aVF, V5, V6 |
| | and | (b) | | I. | there is no LVH |
| | | | or | II. | there is a clinical classification of myocardial infarction |
| | | | or | III. | here is a clinical classification of pericarditis |
| | | | or | IV. | the QRS axis is positive |
| or | 2. | (a) | | | there is a high score for ST elevation in 2 or more of V2, V3 and V4 |
| | and | (b) | | I. | there is no LVH |
| | | | or | II. | there is a clinical classification of myocardial infarction |
| | | | or | III. | there is a clinical classification of pericarditis |

Moderate ST elevation is defined as:

| | | | | | |
|---|---|---|---|---|---|
| | 1. | (a) | | | a moderate score for ST elevation in 2 or more of leads I, II, III, aVL, aVF, V5, V6 |
| | and | (b) | | I. | there is no LVH |
| | | | or | II. | there is a clinical classification of myocardial infarction |
| | | | or | III. | there is a clinical classification of pericarditis |
| | | | or | IV. | the QRS axis is positive |
| or | 2. | (a) | | | there is a moderate score for ST elevation in 2 or more of V2, V3 and V4 |
| | and | (b) | | I. | there is no LVH |
| | | | or | II. | there is a clinical classification of myocardial infarction |
| | | | or | III. | there is a clinical classification of pericarditis |

**Statements (reasons)**

In the diagnostic output relating to ST abnormalities, there is a 'reason' statement printed above or beside the diagnostic statement, e.g.

Inferior ST elevation.

This is essentially integral to the diagnostic statement that follows, e.g.

Inferior ST elevation, CONSIDER ACUTE INFARCT.

The following are the 'reason' comments.

1. Inferior ST elevation

| | | |
|---|---|---|
| | (a) | Q wave inferior infarction is not true |
| and | (b) | there is acute, marked or moderate ST elevation in the inferior leads |

2. Lateral ST elevation

| | | |
|---|---|---|
| | (a) | Q wave lateral and anterolateral infarction are not true |
| and | (b) | there is acute, marked or moderate ST elevation in the lateral leads |

3. Anteroseptal ST elevation

| | | |
|---|---|---|
| | (a) | there is acute, marked or moderate ST elevation in the anteroseptal leads |

4. Anterior ST elevation

| | | |
|---|---|---|
| | (a) | 3 is not true |
| and | (b) | there is acute, marked or moderate ST elevation in the anterior leads |

5. Septal ST elevation

| | | |
|---|---|---|
| | (a) | 3 is not true |
| and | (b) | there is acute, marked or moderate ST elevation in the septal leads |

6. Widespread ST elevation

| | | |
|---|---|---|
| | (a) | there is acute, marked or moderate ST elevation in the inferior leads |
| and | (b) | there is acute, marked or moderate ST elevation in the anterolateral leads |

7. Anterolateral ST elevation

(a) there is acute, marked or moderate ST elevation in the anterolateral leads

Combinations of the above are possible, e.g.

Inferior and lateral ST elevation

8. Widespread ST depression

(a) STj < -0.05mV and ST slope is negative in 6 or more leads exluding V1 and aVR.

and (b) there is no RBBB, LBBB or IVCD.

and (c) there is no LVH with repolarisation.

9. Anteroseptal ST depression

(a) STj < -0.1mV and STj > T- + 0.05mV in V2-V3, and if this is only true for V3 then there is no LVH with repolarization abnormality.

and (b) there is an ACUTE inferior MI

and (c) there is not RBBB or Brugada pattern

10. Marked anteroseptal ST depression

(a) I. ST < -0.3mV in any of V1 - V4 with corresponding ST slope negative, and RBBB and LBBB are false and there is no RVH with repolarization abnormality. In addition, if only V3 and V4 satisfy these criteria, then there is no LVH with repolarization abnormality.

or II. In V2 and V3, ST < -0.1mV with corresponding ST slope negative, |ST-T-| < 0.2mV and there is no acute inferior infarct and RBBB, IVCD, Brugada pattern and (definite) RVH are not present.

or III. ST junction < -0.2mV in V2 and there is ST elevation in any limb lead (as defined for STEMI) and there is no RBBB nor RVH with repolarisation

or IV. ST junction < -0.1mV and ST slope > 75 and T+ > 0.75mV and T+ > max (R,R') in V2 and V3

or (b) LBBB is present and concordant ST junction < -0.1mV and ST slope < 10 in V1, V2 or V3

11. Marked inferior ST depression

(a) I. ST junction < -0.2mV and ST slope < 20 in 2 contiguous inferior leads and |S| > |ST|

and II. there is no LBBB

and III. there is no LVH with repolarisation

or (b) LBBB is present and concordant ST junction < -0.1mV and ST slope < 10 in II, III or aVF

12. Marked lateral ST depression

| | | | | |
|---|---|---|---|---|
| | (a) | | I. | ST junction < -0.1mV and ST slope < 0 in lateral leads I, aVL, V5 and V6. |
| | | and | II. | there is no LBBB |
| | | and | III. | there is no LVH with repolarisation |
| or | (b) | | | LBBB is present and concordant ST junction < -0.1mV and ST slope < 10 in I, aVL, V5 or V6 |

13. End QRS notching/slurring

| | | |
|---|---|---|
| | (a) | There is a notch or slur on the R wave at the end of QRS complex in 2 or more contiguous leads in the inferior leads II, aVF III; the lateral leads I, aVL or the anterolateral leads V4, V5, V6. The ST amplitude at the start of the slur or top of the notch ⩾ 0.1mV |
| and | (b) | There is no LBBB, RBBB or Brugada pattern |
| and | (c) | The QRS duration ⩽120msecs |
| and | (d) | There is no acute Q wave infarction at the relevant site |

**Statements**

If any of 1 to 7 (or combinations) above is true, print one of the following.

1. , CONSIDER ACUTE INFARCT

| | | | | |
|---|---|---|---|---|
| | (a) | | | age ⩾ 18 years |
| and | (b) | | | the STEMI criteria are met |
| and | (c) | | I. | there is no end QRS notching/slurring at the site of infarction |
| | | or | II. | there is high STj amplitude at the infarction site |

2. suggests post-operative pericarditis

| | | |
|---|---|---|
| | (a) | clinical classification includes post operative cardiac surgery |
| and | (b) | extensive ST elevation |

3. probable post-operative pericarditis

| | | |
|---|---|---|
| | (a) | there is a clinical classification of post-operative cardiac surgery |
| and | (b) | there is ST elevation |
| and | (c) | Statement 2 is false |

If reason 13 is true, print the following.

4. - early repolarization pattern

| | | |
|---|---|---|
| | (a) | Statements 1-3 are false |
| and | (b) | there is End QRS notching/slurring as described inreason 13. |

If any of reasons 1 to 7 (or combinations) above is true, print one of the following.

5. suggests pericarditis

| | | | | |
|---|---|---|---|---|
| | (a) | | | Statements 1-4 are false |
| and | (b) | | I. | there is marked inferior and anterolateral ST elevation |
| | | and | II. | there is a high ST elevation score in all anteroseptal leads |
| | | and | III. | there is no QRS notching |

6. consider pericarditis

(a) Statements 1-5 are false
and (b) there is moderate inferior and anterolateral ST elevation
and (c) there is a high ST elevation score in all anteroseptal leads
and (d) there is no QRS notching

7. is consistent with pericarditis

(a) Statements 1-4 are false
and (b) there is a clinical classification of pericarditis
and (c) I. there is marked ST elevation
or II. there is moderate ST elevation in anterolateral and inferior leads

8. cannot rule out myocardial injury

(a) Statements 1-4 are false
and (b) I. LVH is present
and II. there is marked ST elevation in at least 2 of the inferior or lateral leads
and III. QRS axis > 0°
and IV. there is not a clinical classification of myocardial injury or pericarditis or post-operative cardiac surgery

9. is nonspecific

(a) Statements 1-8 are false
and (b) there is marked or moderate ST elevation

### ST depression

The following ST depression statements are only reported if the patient is ⩾ 18 years. Statements 10, 12, 13 and 14 are only reported if the heart rate is <150 bpm, the QRS duration < 170 ms, there is no pacing reported, and the rhythm is not atrial flutter. Ifany of the following sets of criteria is true, then the appropriate reason (8 to 12) isprinted together with the statement.

10. , CONSIDER ACUTE INFARCT (left main occlusion / multivessel disease)

(a) I. there is widespread ST depression as described in Reason 8
and II. ST elevation in aVR > 0.05mV
and III. the maximal ST depression is in V4 or V5
and IV. there is no acute inferior, lateral or anterior infarct

11. is probably reciprocal to inferior infarct

(a) Statement 10 is FALSE
and (b) there is anteroseptal ST depression as described in Reason 9.
and (c) there is an acute inferior infarct

12. accompanies the infarct

(a) Statement 10 is FALSE

and (b) I. there is marked anteroseptal ST depression as described in Reason 10 (a).

or II. there is marked inferior ST depression as described in Reason 11 (a).

or III. there is marked lateral ST depression as described in Reason 12 (a).

and (c) there is an acute infarct in another wall (e.g. in ST elevation in one area and ST depression in another)

13. , CONSIDER ACUTE INFARCT

(a) Statements 10,11 and 12 are FALSE

and (b) I. there is marked anteroseptal depression as described in Reason 10(a)I ,II or III, or 10(b).

or II. there is marked inferior ST depression as described in Reason 11.

or III. there is marked lateral ST depression as described in Reason 12.

14. , CONSIDER ACUTE INFARCT (proximal LAD occlusion)

(a) Statements 10 and 11 are FALSE

and (b) I. there is marked anteroseptal ST depression as described in Reason 10(a)(IV).

and II. ST is positive in aVR

and III. overall QRS duration < 120ms

and IV. there is no acute inferior infarct

# 15 ST-T abnormalities (ischaemia etc.)

**Criteria**

The criteria for ST-T abnormalities are essentially classical in nature relating to ST depression or T wave inversion. In practice, however, their logical relationship to diagnostic statements is somewhat involved. For this reason, a simplified version is set out below.

Define an ST-T abnormality in the lead combinations as follows:

Inferior leads

| | | |
|---|---|---|
| | (a) | there is ST depression or T wave inversion in inferior leads |
| and | (b) | there is not inferior myocardial infarction |
| and | (c) | none of WPW or LBBB is true |

Lateral leads

| | | |
|---|---|---|
| | (a) | there is ST depression or T wave inversion in lateral leads |
| and | (b) | there is not lateral infarction |
| and | (c) | none of WPW or LBBB is true |

Anteroseptal leads

| | | |
|---|---|---|
| | (a) | there is ST depression or T wave inversion in anteroseptal leads |
| and | (b) | there is not (anterior) septal or anterior infarction |
| and | (c) | none of WPW, RBBB, RBBB with left anterior fascicular block, RBBB with left posterior fascicular block, Extensive IVCD or Brugada pattern is true |

Anterior leads

| | | |
|---|---|---|
| | (a) | there is no ST-T abnormality in the anteroseptal leads |
| and | (b) | there is ST depression or T wave inversion in the anterior leads |
| and | (c) | none of WPW, RBBB, RBBB with left anterior fascicular block, RBBB with left posterior fascicular block, Extensive IVCD, LBBB or Brugada pattern is true |

Septal leads

| | | |
|---|---|---|
| | (a) | there is no ST-T abnormality in the anteroseptal or anterior leads |
| and | (b) | there is ST depression or T wave inversion in the septal leads |
| and | (c) | there is not anteroseptal or anterior or septal infarction |
| and | (d) | none of WPW, RBBB, RBBB with left anterior fascicular block, RBBB with left posterior fascicular block, Extensive IVCD or Brugada pattern is true |

Anterolateral leads

| | | |
|---|---|---|
| | (a) | there is an ST and/or T wave abnormality in both anterior and lateral leads as defined above |

Widespread

| | | |
|---|---|---|
| | (a) | there is an ST and/or T wave abnormality in the inferior leads and either the anterolateral or lateral leads together with septal, anteroseptal or anterior leads |

**Statements (reasons)**

There are several possible 'reason' statements that can be produced, namely:

* ST abnormality

ST junctional depression

Widespread ST abnormality

* T wave abnormality

Widespread T wave abnormality

* ST-T abnormality

Widespread ST-T abnormality

The location of the abnormality, denoted *, can be chosen from the following:

- Inferior
- Lateral
- Anteroseptal
- Anterior
- Septal
- Anterolateral

Various combinations can be selected, e.g. Inferior/lateral

The 'reason' statements are essentially integral to the main diagnostic statement which would be meaningless if not preceded by a reason.

**Statements**

If any of the above 'reason' statements is true, it is printed together with one of the following statements, which are presented here in almost a hierarchical form, i.e. a statement towards the end of the list would only be printed if those near the top were not relevant. In the interest of brevity there are marked simplifications in presenting the list.

An example of the output in this section is as follows:

Lateral ST-T abnormality may be due to the hypertrophy and/or ischemia

In the paediatric age range, statements involving "Myocardial Ischaemia" are suppressed and are replaced by an appropriate statement, e.g. "Non-Specific".

1. is nonspecific

| | | | | |
|---|---|---|---|---|
| | (a) | | | there is an T wave abnormality in any lead group |
| and | (b) | | | there is demand pacemaker activity |

2. may be due to the hypertrophy and/or ischemia

| | | | | |
|---|---|---|---|---|
| | (a) | | | LVH or RVH or BVH |
| and | (b) | | | ST-T abnormality |
| and | (c) | | I. | male ⩾ 30 years |
| | | or | II. | female ⩾ 40 years |
| and | (d) | | | patient is not on digitalis |

3. may be due to the hypertrophy and/or ischemia/digitalis effect

(a) criteria 2(a-c) are true

and (b) patient is on digitalis

4. is probably due to the ventricular hypertrophy

(a) LVH or RVH or BVH

and (b) ST-T abnormality

and (c) I. male < 30 years

or II. female < 40 years

and (d) patient is not on digitalis

5. is probably due to the ventricular hypertrophy/digitalis effect

(a) criteria 4(a-c) are true

and (b) patient is on digitalis

6. may be due to myocardial ischemia

(a) there is ST-T abnormality in the lateral leads

and (b) I. there is evidence of anterior or anteroseptal infarction with T wave inversion in the relevant leads

or II. there is inferior infarction with inferior T wave abnormality

7. suggests myocardial infarct

A. (a) there is marked ST depression

and (b) patient is not on digitalis

and (c) there is not atrial flutter or atrial fibrillation,

and (d) there is a clinical classification of myocardial infarction

or B. (a) T- < -0.5mV in V2 or V3 or V4

or (b) T- < -0.35mV in aVF

8. is consistent with pulmonary embolism

(a) clinical classification is pulmonary embolism

and (b) patient is not on digitalis

and (c) I. 7(a), (c) are true and there is ST-T abnormality in the (antero) septal leads

or II. there is moderate ST-T abnormality in certain combinations of leads

9. suggests myocardial injury/ischemia

(a) 7(a)(b)(c) are true

and (b) clinical classification is not myocardial infarction, pulmonary embolism or post operative cardiac surgery in the presence of certain groups of ST-T abnormalities

10. is probably due to cardiac surgery

(a) clinical classification is post operative cardiac surgery

and (b) I. there is widespread T wave inversion

or II. there is T wave abnormality in at least two groups of leads

11. may be due to myocardial infarct or CVA

| | | |
|---|---|---|
| | (a) | there is T wave inversion in the lateral or anteroseptal leads |
| and | (b) | T- < -1.0mV in V3, V4 or V5 |

12. is consistent with endocrine disease

| | | |
|---|---|---|
| | (a) | T wave abnormality (but not in anteroseptal leads only) |
| and | (b) | clinical classification is endocrine disease |
| and | (c) | the heart rate < 60 bpm |
| and | (d) | the patient is not on digitalis |

13. is possibly secondary to hypertension

| | | |
|---|---|---|
| | (a) | moderate T wave abnormality in the inferior and/or lateral leads |
| and | (b) | clinical classification is hypertension |
| and | (c) | patient is not on digitalis |

14. is possibly secondary to hypertension/digitalis effect

| | | |
|---|---|---|
| | (a) | 13(a) and 13(b) are true |
| and | (b) | patient is on digitalis |

15. may be secondary to hypertension/ischemia

| | | |
|---|---|---|
| | (a) | moderate T wave abnormality including inferior and lateral leads in addition to T wave abnormality in other leads |
| and | (b) | clinical classification is hypertension |
| and | (c) | patient is not on digitalis |

16. may be due to digitalis/hypertension

| | | |
|---|---|---|
| | (a) | 15(a) and (b) are true |
| and | (b) | patient is on digitalis |

17. is possibly secondary to congenital heart disease

| | | |
|---|---|---|
| | (a) | there is ST and/or T wave abnormality |
| and | (b) | clinical classification is congenital heart disease |
| and | (c) | patient is not on digitalis |

18. is possibly secondary to valvular heart disease

| | | |
|---|---|---|
| | (a) | there is ST and/or T wave abnormality |
| and | (b) | clinical classification is rheumatic heart disease |
| and | (c) | patient is not on digitalis |

19. is possibly secondary to valvular heart disease/digitalis

| | | |
|---|---|---|
| | (a) | 18(a) and (b) are true |
| and | (b) | patient is on digitalis |

20. is possibly secondary to respiratory disease

| | | | |
|---|---|---|---|
| | (a) | | there is ST or T wave abnormality in the inferior leads with or without another ST-T abnormality |
| and | (b) | | clinical classification is respiratory disease |
| and | (c) | | P+ amplitude in aVF > 0.3mV |
| and | (d) | | QRS axis > 60° if ST-T abnormality other than inferior are present |
| and | (e) | | patient is not on digitalis |

21. is age related : consider juvenile T waves

| | | | |
|---|---|---|---|
| | (a) | | T wave abnormality in (anterior) septal leads |
| and | (b) | | age < 18 years |

22. is non-specific : may be normal for age and race

| | | | |
|---|---|---|---|
| | (a) | | 21(a) is true |
| and | (b) | | black with age < 40 years |

corpuls3 does not support race as an input.

23. may be age and gender related: consider normal variant

| | | | | |
|---|---|---|---|---|
| | (a) | | | T wave abnormality in the inferior leads with or without changes in the lateral leads |
| and | (b) | | I. | the patient is female with age < 35 years |
| | | or | II. | the patient is male with age < 30 years |
| and | (c) | | | patient is not on digitalis |
| and | (d) | | | no previous statement is true and clinical classification is not myocardial infarction or ischaemia |

24. is consistent with digitalis effect

| | | |
|---|---|---|
| | (a) | female with age < 35 years or male with age < 30years |
| and | (b) | no previous statement is true and clinical classification is not myocardial infarction or ischaemia |
| and | (c) | patient is on digitalis |
| and | (d) | clinical classification is not pulmonary embolism or post-operative with certain groups of ST-T abnormalities |

25. suggests myocardial ischemia

| | | |
|---|---|---|
| | (a) | marked T wave abnormality in any group or groupsof leads |
| and | (b) | clinical classification is myocardial infarction or myocardial ischaemia |
| and | (c) | patient is not on digitalis |

26. suggests ischemia/digitalis effect

| | | |
|---|---|---|
| | (a) | 25(a) and (b) are true |
| and | (b) | patient is on digitalis |

27. may be due to myocardial ischemia

| | | |
|---|---|---|
| | (a) | ST-T abnormality in any group of leads |
| and | (b) | no previous statement true |
| and | (c) | patient is not on digitalis |
| and | (d) | clinical classification is not myocardial infarction or ischaemia |
| and | (e) | age > 30 years if male or age > 40 years if female |

28. suggests possible myocardial ischemia/digitalis effect

| | | |
|---|---|---|
| | (a) | 27(a)(b)(d)(e) are true |
| and | (b) | patient is on digitalis |

29. is age and gender related

| | | |
|---|---|---|
| | (a) | 27(a) to (d) are true |
| and | (b) | age ⩽ 30 years if male or age ⩽ 40 years if female |

30. is age and gender related – possible digitalis effect

| | | |
|---|---|---|
| | (a) | 29(a) and (b) are true |
| and | (b) | patient is on digitalis |

31. is consistent with myocardial ischemia

| | | |
|---|---|---|
| | (a) | moderate ST and/or T wave abnormality in any group or group of leads |
| and | (b) | clinical classification of myocardial infarction or myocardial ischaemia |
| and | (c) | patient is not on digitalis |

32. is consistent with ischemia/digitalis effect

| | | |
|---|---|---|
| | (a) | 31(a) and (b) is true |
| and | (b) | patient is on digitalis |

33. - possible digitalis effect

| | | |
|---|---|---|
| | (a) | 31(a) is true |
| and | (b) | 31(b) is false and clinical classification is not normal |
| and | (c) | patient is on digitalis |
| and | (d) | age > 30 years if male or age > 40 years if female |

34. is borderline

| | | |
|---|---|---|
| | (a) | 31(a) is true |
| and | (b) | clinical classification is normal |
| and | (c) | patient is not on digitalis |
| and | (d) | age > 30 years if male or age > 40 years if female |

35. is borderline for age and gender

| | | |
|---|---|---|
| | (a) | 31(a) is true |
| and | (b) | clinical classification is not normal or unknown |
| and | (c) | patient is not on digitalis |
| and | (d) | age ⩽ 30 years if male or age ⩽ 40 years if female |

36. is borderline for age and gender – possible digitalis effect

| | | |
|---|---|---|
| | (a) | 35(a)(b)(d) are true |
| and | (b) | patient is on digitalis |

37. is consistent with digitalis effect

| | | |
|---|---|---|
| | (a) | none of the previous statement is true |
| and | (b) | there is widespread borderline ST and/or T wave abnormality |
| and | (c) | patient is on digitalis |

38. is probably due to digitalis effect

| | | |
|---|---|---|
| | (a) | there is borderline ST and/or T wave abnormality in any group of leads |
| and | (b) | patient is on digitalis |

39. suggests digitalis effect/ischemia

| | | |
|---|---|---|
| | (a) | none of the previous statements is true |
| and | (b) | patient is on digitalis |
| and | (c) | age ⩾ 35 years if female or age ⩾ 30 years if male |

40. is nonspecific

| | | | |
|---|---|---|---|
| | A. | (a) | 31(a) is true |
| | and | (b) | 31(b) is false and clinical classification is not normal |
| | and | (c) | patient is not on digitalis |
| | and | (d) | age > 30 years if male or age > 40 years if female |
| or | B. | (a) | none of the previous statement is true |
| | and | (b) | there is widespread borderline ST and/or T wave abnormality |

41. is nonspecific

| | | |
|---|---|---|
| | (a) | there is no T wave abnormality or ST segment depression but there is junctional ST depression |
| and | (b) | there is no myocardial infarction, conduction defect or WPW pattern result |
| and | (c) | there is not LVH with ST/T reasons, |
| and | (d) | the ST slope > 0° with the ST amplitude ⩽ -0.02mV for any TWO leads (excluding aVR) |

# 16 Miscellaneous

## 16.1 Low QRS voltages

**Statements**

1. Low QRS voltages in limb leads
   - (a) peak to peak QRS voltage < 0.5mV for all of Leads I, II and III

2. Low QRS voltages in precordial leads
   - (a) I. female
     - and II. peak to peak QRS voltage < 0.8mV for all of leads V1, V2, V3, V4, V5 and V6
   - or (b) I. male
     - and II. peak to peak QRS voltage < 1.0mV for all of leads V1, V2, V3, V4, V5 and V6

3. Generalized low QRS voltages
   - (a) both statements 1 and 2 are true

4. Generalized low QRS voltages – consider pericardial effusion
   - (a) peak to peak voltage < 75% of thresholds specified instatements 1 and 2

## 16.2 Tall T waves

**Statements**

1. Tall T waves – consider acute ischemia or hyperkalemia
   - (a) age >= 30 years
   - and (b) T+ amplitude > an age and sex dependent limit in all leads V3 to V5, as detailed in the table below
   - and (c) Left Bundle Branch Block is not present

2. Tall T waves – consider hyperkalemia
   - (a) age < 30 years
   - and (b) T+ amplitude > an age and sex dependent limit in allleads V3 to V5, as detailed in the table below
   - and (c) Left Bundle Branch Block is not present

Table of age and sex dependent limits:

| | Age < 30 years | Age ⩾ 30 years |
|---|---|---|
| Female | 0.9 mV | 0.75 mV |
| Male | 1.6 mV | 1.2 mV |

## 16.3 Critical values

There are seven critical value statements that can be generated by the analysis. Each critical value statement will be output based upon the presence of specific statements that appear on the report or if the heart rate exceeds an age related threshold. The available critical value statements are as follows:-

1. *** ACUTE STEMI ***

This statement will be output if the relevant ST amplitudes exceed the higher level of ST amplitudes (as described in the section headed MYOCARDIAL INFARCTION), and any of the following statements appear on the report:-

++ ST elevation, CONSIDER ACUTE INFARCT

POSSIBLE ACUTE ++ INFARCT

*** ++ INFARCT - POSSIBLY ACUTE ***

where ++ = inferior, lateral, anteroseptal etc.

2. *** POSSIBLE ACUTE STEMI ***

This statement will be output if the relevant ST amplitudes exceed the upper limits for normal ST amplitudes (as described in the section headed MYOCARDIAL INFARCTION), but not the higher limits of ST amplitudes, and any of the following statements appear on the report:-

++ ST elevation, CONSIDER ACUTE INFARCT

POSSIBLE ACUTE ++ INFARCT

*** ++ INFARCT - POSSIBLY ACUTE ***

where ++ = inferior, lateral, anteroseptal etc.

3. *** ACUTE MI/ISCHEMIA ***

This statement will be output if any of the following statements appear on the report:-

Marked ++ ST depression, CONSIDER ACUTE INFARCT

Marked anteroseptal ST depression, CONSIDER ACUTE INFARCT (proximal LAD occlusion)

Widespread ST depression, CONSIDER ACUTE INFARCT (left main occlusion /multivessel disease)

where ++ = inferior, lateral, anteroseptal

4. *** EXTREME TACHYCARDIA ***

This statement will be output if the heart rate exceeds the limit for age shown in the table below:-

| Age range | Rates in beats/min |
|---|---|
| Birth - 28 days | 213 → 230 |
| 29 days - 180 days | 230 |
| 181 days - 17 years | 230 → 150 |
| ⩾ 18 years | 150 |

5. *** EXTREME BRADYCARDIA ***

This statement will be output if the heart rate is below the limit for age shown in the table below:

| Age range | Rates in beats/min |
|---|---|
| Birth - 28 days | 73 → 90 |
| 29 days - 365 days | 90 |
| 1 year - 6 years | 90 → 45 |
| 6 years - 12.5 years | 45 → 40 |
| > 12.5 years | 40 |

6. *** SIGNIFICANT ARRHYTHMIA ***

This statement will be output if any of the following statements appear on the report:-

Supraventricular tachycardia
Probable supraventricular tachycardia
Probable ventricular tachycardia
Consider ventricular flutter/fibrillation
Accelerated idioventricular rhythm
Possible idioventricular rhythm
Wide QRS tachycardia - possible supraventricular tachycardia
Wide QRS tachycardia - possible ventricular 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

7. *** PROLONGED QTc INTERVAL ***

(a) QTc > 520ms
and (b) overall QRS duration < 120ms
and (c) heart rate ⩽ 125bpm

# 17 Rhythm statements

The rhythm section of the program will always select one statement (only) from the list of dominant rhythms and if appropriate will select up to three additional statements from the list of supplementary statements.

**Dominant rhythm statements**

Sinus rhythm

Sinus tachycardia

Sinus bradycardia

Sinus arrhythmia

Sinus tachycardia with sinus arrhythmia

Sinus bradycardia with sinus arrhythmia

Atrial tachycardia

Atrial flutter

Atrial fibrillation

Junctional rhythm

Accelerated junctional rhythm

Junctional bradycardia

Atrial pacing

Ventricular pacing

A-V sequential pacemaker

Pacemaker rhythm

Possible ectopic atrial rhythm

Possible ectopic atrial tachycardia

Possible ectopic atrial bradycardia

Irregular ectopic atrial rhythm

Irregular ectopic atrial tachycardia

Irregular ectopic atrial bradycardia

Probable atrial tachycardia

Probable sinus tachycardia

Probable supraventricular tachycardia

Marked sinus bradycardia

Probable atrial flutter

Probable atrial fibrillation

Probable junctional rhythm

Probable accelerated junctional rhythm

Probable ventricular tachycardia

Consider ventricular flutter/fibrillation

Wide QRS tachycardia - possible supraventricular tachycardia

Wide QRS tachycardia - possible ventricular tachycardia

Accelerated idioventricular rhythm

Possible idioventricular rhythm

Possible atrial flutter

Possible junctional rhythm
Possible accelerated junctional rhythm
Possible junctional bradycardia
A-V dissociation
Undetermined rhythm
Regular supraventricular rhythm
Irregular supraventricular rhythm

**Supplementary rhythm statements**

with frequent PVCs
with multifocal PVCs
with frequent multifocal PVCs
with interpolated PVC(s)
with multifocal interpolated PVCs
with PVC(s)
with PAC(s)
with frequent PACs
with aberrantly conducted supraventricular complexes
with 1st degree A-V block
with borderline 1st degree A-V block
with 2nd degree A-V block, Mobitz I (Wenckebach)
with 2nd degree A-V block, Mobitz II
with 2:1 A-V block
with 3:1 A-V block
with 4:1 A-V block
with high degree A-V block
with varying 2nd degree A-V block
with complete A-V block
with 2nd degree (Mobitz II) SA Block
with bigeminal PACs
with bigeminal PVCs
Demand atrial pacing
Demand pacing
with fusion complexes
with non-sustained ventricular tachycardia
with intermittent conduction defect
with paroxysmal idioventricular rhythm
with unclassified aberrant complexes
with undetermined ectopic complexes
with undetermined irregularity

The following four statements are added to other rhythm statements where appropriate.

or aberrant ventricular conduction
with rapid ventricular response
with uncontrolled ventricular response
with slow ventricular response

# 18 Summary codes

There are six summary codes available. Each diagnostic statement and dominant or supplementary rhythm statement is assigned a summary code and the highest code present in an interpretation is then printed. The various codes in ascending order are as follows:

1. Normal ECG
2. Normal ECG except for rate
3. Normal ECG based on available leads
4. Borderline ECG
5. Abnormal ECG
6. Technical error

# 19 Measurement matrix

The electrocardiographs can be programmed so that the Measurement Matrix is written out after the analysis report.

The Measurement Matrix consists of 15 columns which contain measurements for the twelve standard leads and optionally 3 additional leads as specified by the user when using a 15-lead analysis. The 12 columns are labelled I, II, III, aVR, aVL, aVF, V1, V2,V3 (or V4R for paediatric lead placement), V4, V5, V6.

The content of the matrix is explained below:

| Row | Content | Description | Units |
|---|---|---|---|
| 1 | P onset | Time from the beginning of the representative beat to the beginning of the P wave. | msec |
| 2 | P duration | P wave duration | msec |
| 3 | QRS onset | Time from the beginning of the representative beat to the beginning of the QRS complex. | msec |
| 4 | QRS duration | QRS complex duration | msec |
| 6 | Q duration | Q wave duration | msec |
| 7 | R duration | R wave duration | msec |
| 8 | S duration | S wave duration | msec |
| 9 | R' duration | R' wave duration | msec |
| 10 | S' duration | S' wave duration | msec |
| 14 | T onset | Time from the beginning of the representative beat to the beginning of the T wave | msec |
| 16 | P+ duration | P+ wave duration | msec |
| 18 | QRS intrinsicoid deflection | QRS Intrinsicoid deflection time | msec |
| 19 | P+ amplitude | P+ wave amplitude | µV |
| 20 | P- amplitude | P- wave | µV |
| 21 | Peak to peak QRS | Peak to peak amplitude of the QRS complex. | µV |
| 23 | Q amplitude | Q wave | µV |
| 24 | R amplitude | R wave amplitude | µV |
| 25 | S amplitude | S wave amplitude | µV |
| 26 | R' amplitude | R' wave amplitude | µV |
| 27 | S' amplitude | S' wave amplitude | µV |
| 30 | ST amplitude | ST wave amplitude | µV |
| 31 | 2/8 ST-T amp | Amplitude at a point which is 2/8 of the ST-Tinterval. | µV |
| 32 | 3/8 ST-T amp | Amplitude at a point which is 3/8 of the ST-Tinterval. | µV |
| 33 | T+ amplitude | T+ wave amplitude | µV |
| 34 | T- amplitude | T- wave amplitude | µV |
| 35 | QRS area | Total area of the QRS complex scaled down by a factor of 20 | µV |
| 39 | T morphology | T wave morphology | µV-msec /20 |
| 40 | R wave notch | R wave notch count | |
| 41 | Delta Waveconfidence | Probability of the presence of a delta wave. | % |

| Row | Content | Description | Units |
|---|---|---|---|
| 42 | ST slope | ST slope from the J point to the 3/8 ST-T point | degrees |
| 47 | QT interval | Duration of QT interval | msec |
| 51 | QRS notch/slur | Amplitude at start of end QRS notch or slur | µV |
| 52 | PR amplitude | Difference in amplitude from that at P onset to amplitude at QRS onset | µV |
| 53 | ST adjustedampli-tude | ST amplitude adjusted (to take PR amplitude into account, if applicable) | µV |

# 20 List of statements

The complete list of statements produced by the Glasgow Program is listed below.

**Preliminary comments**

Possible faulty V2 - omitted from analysis

Possible faulty V3 - omitted from analysis

Possible faulty V4 - omitted from analysis

Possible faulty V5 - omitted from analysis

Possible faulty V6 - omitted from analysis

Possible sequence error: V1,V2 omitted

Possible sequence error: V2,V3 omitted

Possible sequence error: V3,V4 omitted

Possible sequence error: V4,V5 omitted

Possible sequence error: V5,V6 omitted

Lead(s) unsuitable for analysis:

~ I

~ II

~ III

~ aVR

~ aVL

~ aVF

~ V1

~ V2

~ V3

~ V4

~ V5

~ V6

~ V4R

--- Possible measurement error ---

**Lead reversal/dextrocardia**

--- Possible arm lead reversal - only aVF, V1-V6 analyzed ---

--- Suggests dextrocardia ---

--- Possible limb lead reversal – hence only V1-V6 analyzed ---

--- Possible arm/leg lead interchange – hence only V1-V6 analyzed ---

**Restricted analysis**

Pacemaker rhythm - no further analysis

--- No further analysis due to lack of dominant QRS ---

--- Similar QRS in V leads ---

--- Technically unsatisfactory tracing ---

**Miscellaneous preliminary statements**

If rhythm is confirmed, the following report may not be valid

--- Invalid clinical data entry ---

--- Invalid medication entry ---

--- Interpretation made without knowing patient's gender ---

--- Interpretation made without knowing patient's age ---

--- Interpretation made without knowing patient's gender/age ---

**Pediatric ECG analysis**

--- Interpretation based on pediatric criteria ---

**Intervals**

Short PR interval

Borderline prolonged QT interval

Prolonged QT - consider ischemia, electrolyte imbalance, drug effects

Short QT interval

**Atrial abnormalties**

Possible right atrial abnormality

Consider left atrial abnormality

Possible right atrial abnormality consistent with pulmonary disease

Possible left atrial abnormality

Possible biatrial enlargement

**Critical values**

*** ACUTE STEMI ***

*** POSSIBLE ACUTE STEMI ***

*** ACUTE MI/ISCHEMIA ***

*** EXTREME TACHYCARDIA ***

*** EXTREME BRADYCARDIA ***

*** SIGNIFICANT ARRHYTHMIA ***

*** PROLONGED QTc INTERVAL ***

**QRS axis deviation**

Indeterminate axis

Leftward axis

Left axis deviation

Marked left axis deviation

QRS axis leftward for age

Rightward axis

Right axis deviation

Marked right axis deviation

Left anterior fascicular block
Possible left anterior fascicular block
Possible left posterior fascicular block
Severe right axis deviation

**Conduction defects**

Left bundle branch block
Incomplete LBBB
Right bundle branch block
RBBB with left anterior fascicular block
RBBB with RAD - possible left posterior fascicular block
IV conduction defect
Incomplete RBBB
rSr'(V1) - probable normal variant

**WPW pattern**

WPW pattern - probable left posterolateral accessory pathway
WPW pattern - probable left posteroseptal accessory pathway
WPW pattern - probable left anterolateral accessory pathway
WPW pattern - probable right posteroseptal accessory pathway
WPW pattern - probable midseptal accessory pathway
WPW pattern - probable anteroseptal accessory pathway
WPW pattern - probable right anterolateral accessory pathway
WPW pattern - probable right posterolateral accessory pathway

**Brugada pattern**

Marked ST elevation - consider Brugada pattern

**Hypertrophy**

Left ventricular hypertrophy
Left ventricular hypertrophy, possible digitalis effect
Borderline high QRS voltage - probable normal variant
Possible left ventricular hypertrophy
Possible left ventricular hypertrophy, possible digitalis effect
Left ventricular hypertrophy by voltage only
Right ventricular hypertrophy
Right ventricular hypertrophy, possible digitalis effect
Possible right ventricular hypertrophy
Possible right ventricular hypertrophy, possible digitalis effect
Biventricular hypertrophy
Possible biventricular hypertrophy

**Myocardial infarction**

Inferior infarct - age undetermined
*** INFERIOR INFARCT - POSSIBLY ACUTE ***
Possible inferior infarct - age undetermined
Small inferior Q waves noted: infarct cannot be excluded
Small inferior Q waves noted: probably normal ECG
Abnormal Q waves of undetermined cause
Inferior Q waves may be due to cardiomyopathy
Lateral infarct - age undetermined
*** LATERAL INFARCT - POSSIBLY ACUTE ***
Possible lateral infarct - age undetermined
Small lateral Q waves noted: probably normal ECG
Lateral Q waves may be due to cardiomyopathy
Anteroseptal infarct - age undetermined
*** ANTEROSEPTAL INFARCT - POSSIBLY ACUTE ***
Possible anteroseptal infarct - age undetermined
Anteroseptal QRS changes may be due to ventricular hypertrophy
Anteroseptal QRS changes may be due to corrected transposition
Cannot rule out anteroseptal infarct - age undetermined
QRS changes may be due to LVH but cannot rule out anteroseptal infarct
Poor R wave progression - cannot rule out anteroseptal infarct
Poor R wave progression consistent with pulmonary disease
Poor R wave progression
Anterior infarct - age undetermined
*** ANTERIOR INFARCT - POSSIBLY ACUTE ***
Possible anterior infarct - age undetermined
Anterior QRS changes may be due to ventricular hypertrophy
Anterior QRS changes may be due to corrected transposition
Cannot rule out anterior infarct - age undetermined
QRS changes V3/V4 may be due to LVH but cannot rule out anterior infarct
Anterior QRS changes are probably related to pulmonary disease
*** SEPTAL INFARCT - POSSIBLY ACUTE ***
Possible septal infarct - age undetermined
Septal QRS changes may be due to ventricular hypertrophy
Septal QRS changes may be due to corrected transposition
Cannot rule out septal infarct - age undetermined
QRS changes in V2 may be due to LVH but cannot rule out septal infarct
Q in V1/V2 may be normal variant but septal infarct cannot be excluded
Q in V1/V2 may be due to lead placement error though septal infarct cannot be excluded
Q in V1/V2 may be due to LVH though septal infarct cannot be excluded
Poor R wave progression may be due to pulmonary disease
Poor R wave progression - cannot rule out septal infarct

Possible posterior infarct - age undetermined
Possible posterior extension of infarct
Tall R V1/V2 probably reflect the infarct
Anterolateral infarct - age undetermined
*** ANTEROLATERAL INFARCT - POSSIBLY ACUTE ***
Possible anterolateral infarct - age undetermined
Extensive infarct - age undetermined
*** EXTENSIVE INFARCT - POSSIBLY ACUTE ***
Possible extensive infarct - age undetermined
Q waves may be due to cardiomyopathy

**ST abnormalities**

Marked anteroseptal ST depression
Marked inferior ST depression
Marked lateral ST depression
Anteroseptal ST depression
Widespread ST depression
Widespread ST elevation
Anterolateral ST elevation
Inferior and lateral ST elevation
Inferior and ant/septal ST elevation
Inferior and septal ST elevation
Inferior and anterior ST elevation
Anteroseptal ST elevation
Anterior ST elevation
Septal ST elevation
Lateral ST elevation
Inferior ST elevation
End QRS notching/slurring
~ is probably reciprocal to inferior infarct
~, CONSIDER ACUTE INFARCT
~, CONSIDER ACUTE INFARCT (proximal LAD occlusion)
accompanies the infarct
~, CONSIDER ACUTE INFARCT (left main occlusion / multivessel disease)
~ is consistent with pericarditis
~ - cannot rule out myocardial injury
~ - consider pericarditis
~ suggests pericarditis
~ suggests post operative pericarditis
~ - early repolarization pattern
~ - probable post operative pericarditis
~ is nonspecific

**ST-T changes (ischemia)**

ST junctional depression
Widespread T wave abnormality
Widespread ST abnormality
Widespread ST-T abnormality
Anterolateral T wave abnormality
Anterolateral ST abnormality
Anterolateral ST-T abnormality
Ant/septal and lateral T wave abnormality
Ant/septal and lateral ST abnormality
Ant/septal and lateral ST-T abnormality
Septal and lateral T wave abnormality
Septal and lateral ST abnormality
Septal and lateral ST-T abnormality
Septal T wave abnormality
Septal ST abnormality
Septal ST-T abnormality
Lateral T wave abnormality
Lateral ST abnormality
Lateral ST-T abnormality
Inferior and ant/septal T wave abnormality
Inferior and ant/septal ST abnormality
Inferior and ant/septal ST-T abnormality
Inferior and anterior T wave abnormality
Inferior and anterior ST abnormality
Inferior and anterior ST-T abnormality
Inferior and septal T wave abnormality
Inferior and septal ST abnormality
Inferior and septal ST-T abnormality
Inferior T wave abnormality
Inferior ST abnormality
Inferior ST-T abnormality
Anteroseptal T wave abnormality
Anteroseptal ST abnormality
Anteroseptal ST-T abnormality
Anterior T wave abnormality
Anterior ST abnormality
Anterior ST-T abnormality
Inferior/lateral T abnormality
Inferior/lateral ST abnormality
Inferior/lateral ST-T abnormality

~ is probably due to cardiac surgery
~ is consistent with digitalis effect
~ is consistent with pulmonary embolism
~ is nonspecific
~ is consistent with endocrine disease
~ is possibly secondary to hypertension
~ is possibly secondary to congenital heart disease
~ is possibly secondary to valvular heart disease
~ is possibly secondary to respiratory disease
~ is possibly secondary to hypertension/digitalis effect
~ is possibly secondary to valvular heart disease/digitalis
~ is consistent with digitalis effect
~ is probably due to digitalis effect
~ is borderline
~ is age related : consider juvenile T waves
~ is non-specific : may be normal for age and race

corpuls3 does not support race as an input.

~ may be age and gender related : consider normal variant
~ is age and gender related
~ is age and gender related - possible digitalis effect
~ is borderline for age and gender
~ is borderline for age and gender - possible digitalis effect
~ suggests myocardial ischemia
~ suggests ischemia/digitalis effect
~ suggests myocardial infarct
~ may be due to myocardial infarct or CVA
~ suggests myocardial infarct
~ suggests myocardial injury/ischemia
~ may be due to myocardial ischemia
~ suggests possible myocardial ischemia/digitalis effect
~ - possible digitalis effect
~ is consistent with myocardial ischemia
~ is consistent with ischemia/digitalis effect
~ suggests digitalis effect/ischemia
~ may be due to myocardial ischemia
~ may be secondary to hypertension/ischemia
~ may be due to digitalis/hypertension
~ may be due to the hypertrophy and/or ischemia
~ may be due to the hypertrophy and/or ischemia/digitalis effect
~ is probably due to the ventricular hypertrophy
~ is probably due to the ventricular hypertrophy/digitalis effect

**Miscellaneous - low QRS voltages**

Low QRS voltages in limb leads

Low QRS voltages in precordial leads

Generalized low QRS voltages

Generalized low QRS voltages – consider pericardial effusion

**Miscellaneous – tall T waves**

Tall T waves - consider acute ischemia or hyperkalemia

Tall T waves - consider hyperkalemia

**Dominant rhythm statements**

Sinus rhythm

Sinus tachycardia

Sinus bradycardia

Sinus arrhythmia

Sinus tachycardia with sinus arrhythmia

Sinus bradycardia with sinus arrhythmia

Atrial tachycardia

Atrial flutter

Atrial fibrillation

Junctional rhythm

Accelerated junctional rhythm

Junctional bradycardia

Atrial pacing

Ventricular pacing

A-V sequential pacemaker

Pacemaker rhythm

Possible ectopic atrial rhythm

Possible ectopic atrial tachycardia

Possible ectopic atrial bradycardia

Irregular ectopic atrial rhythm

Irregular ectopic atrial tachycardia

Irregular ectopic atrial bradycardia

Probable atrial tachycardia

Probable sinus tachycardia

Probable supraventricular tachycardia

Marked sinus bradycardia

Probable atrial tachycardia

Probable atrial flutter

Probable atrial fibrillation

Probable junctional rhythm

Probable accelerated junctional rhythm
Probable supraventricular tachycardia
Probable ventricular tachycardia
Consider ventricular flutter/fibrillation
Accelerated idioventricular rhythm
Possible idioventricular rhythm
Possible atrial flutter
Possible junctional rhythm
Possible accelerated junctional rhythm
Possible junctional bradycardia
Wide QRS tachycardia - possible supraventricular tachycardia
Wide QRS tachycardia - possible ventricular tachycardia
A-V dissociation
Regular supraventricular rhythm
Irregular supraventricular rhythm
Undetermined rhythm

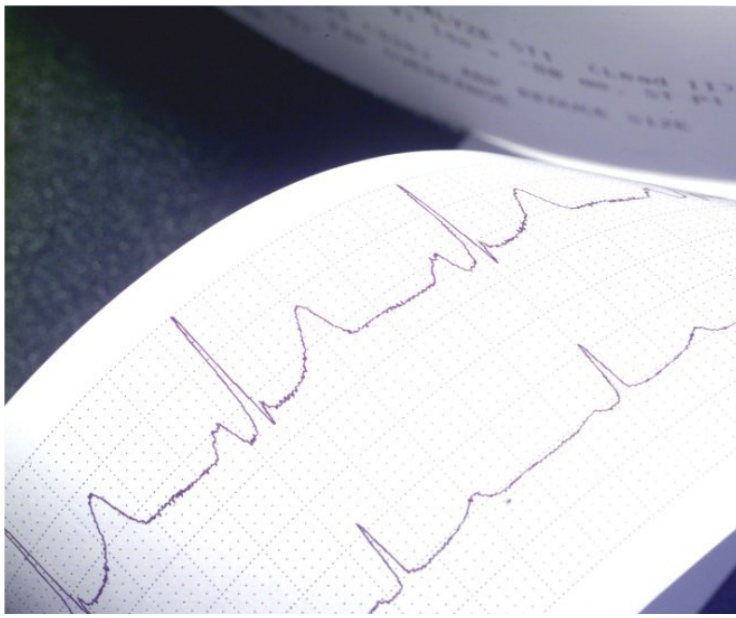
**Supplementary rhythm statements**

~ with PVC(s)
~ with frequent PVCs
~ with multifocal PVCs
~ with frequent multifocal PVCs
~ with interpolated PVC(s)
~ with multifocal interpolated PVCs
~ with paroxysmal idioventricular rhythm
~ with multifocal PVCs
~ with multifocal interpolated PVCs
~ with frequent multifocal PVCs
~ with non-sustained ventricular tachycardia
~ with intermittent conduction defect
~ with rapid ventricular response
~ with uncontrolled ventricular response
~ with slow ventricular response
~ with PACs
~ with frequent PACs
~ with 1st degree A-V block
~ with borderline 1st degree A-V block
~ with 2nd degree A-V block, Mobitz I (Wenckebach)
~ with 2nd degree A-V block, Mobitz II
~ with 2:1 A-V block
~ with 3:1 A-V block
~ with 4:1 A-V block

~ with high degree A-V block
~ with varying 2nd degree A-V block
~ with complete A-V block
~ with 2nd degree (Mobitz II) SA block
~ with bigeminal PACs
~ with bigeminal PVCs
~ with fusion complexes
~ or aberrant ventricular conduction
Demand atrial pacing
Demand pacing
~ with aberrantly conducted supraventricular complexes
~ with unclassified aberrant complexes
~ with undetermined ectopic complexes
~ with undetermined irregularity

**Summary statements**

Normal ECG
Normal ECG except for rate
Normal ECG based on available leads
Borderline ECG
Abnormal ECG
Technical error



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**GS Elektromedizinische Geräte GmbH**
Hauswiesenstraße 26 | 86916 Kaufering

Telefon + 49 8191 65722-0
Fax + 49 8191 65722-22
E-mail info@corpuls.com
Web www.corpuls.world

Medical Technology
Made in Germany

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