ECG Analysis for Resting 12-lead ECG Physician's Guide

For use with Office Medic™ and CardioView™ v4.4 and higher,
Pocket Medic™ v3.2 and higher and PocketView™ v1.2 and higher

Technology in Practice™

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CHAPTER 1 – INTRODUCTION

About the Analysis Module

The ECG Analysis Program is a software component that provides analysis and interpretation of 12 channel ECGs. The ECG analysis program was developed and tested by Cardionics SA in conjunction with the Université Catholique de LOUVAIN (UCL). The ECG analysis program has also been independently evaluated by the Common Standards for Quantitative Electrocardiography (CSE) Coordinating Center.

Conventions

- R* means the R wave duration.
- Q* means the Q wave duration.
- R'* means the R' wave duration.
- I represents Lead I.
- R(I) represent the R wave amplitude in Lead I (in mV).
- R*(I) represent the R wave duration in Lead I (in ms).
- HR = Heart Rate

An index representing the mass of the patient is calculated according to the sex, height and weight of the patient:

$$Index = Weight \ / (Height \times Height) \ kg/m^2$$

- If this Index is < 18 in a man and < 17 in a woman, the patient is considered lightweight.
- If this Index is > 28 in a man and > 27 in a woman, the patient is considered overweight.
- If neither height nor weight data are available, the Index is set at 20 (normal patient).

This Index is of particular usefulness to set the detection thresholds of left ventricular hypertrophies.

Analysis Statements in this Guide are produced by the software program after interpretation of the ECG file. Statements are followed by a number in paranthesis. This number is the code for the statement and is only used only by the software. Any reference within the criteria to a number is a reference to a Statement Code only. The descriptions and calculations below the Statements are intended to provide the interpreting physician with an understanding of how the software determines each possible statement.

CHAPTER 2 – RHYTHM CRITERIA

Rhythm Statements

- **Pacemaker rhythm (001)**
  Spike is present before the QRS complex.

- **Regular rhythm (002)**
  a. Regular rhythm.
  AND b. Atrial ectopic beats.
  AND c. P wave negative in V1.

- **Flutter cannot be ruled out (003)**
  a. Flutter detected with low probability.
  AND b. Regular rhythm.

- **Normal sinus rhythm (004)**
  a. Regular rhythm.
  AND b. P wave positive in V1.
  AND c. 60 < HR < 100 bpm.

- **Sinus bradycardia (005)**
  a. Regular rhythm and HR < 60 bpm.
  OR b. Irregular rhythm and HR < 60 bpm.

- **Marked sinus bradycardia (006)**
  a. Regular rhythm.
  AND b. P wave positive in V1.
  AND c. HR < 45 bpm.

- **Sinus tachycardia (007)**
  a. Regular rhythm and HR > 100 bpm.
  OR b. Irregular rhythm and HR > 100 bpm.

- **Sinus rhythm with 1st degree AV block (008)**

a. True if following conditions are met:
   1. One QRS class.

AND 2. Regular rhythm.

AND 3. 60 < HR < 100 bpm.

AND 4. PR interval > 200 ms.

OR b. True if following conditions are met:
   1. Two QRS classes.

AND 2. Regular rhythm for class 1.

AND 3. 60 < HR < 100 bpm.

AND 4. PR interval > 200 ms.

- **Sinus bradycardia with 1st degree AV block (009)**

a. True if the following conditions are met:
   1. One QRS class.

AND 2. Regular rhythm.

AND 3. HR < 60 bpm.

AND 4. PR interval > 200 ms.

OR b. True if the following conditions are met:
   1. Two QRS classes.

AND 2. Irregular rhythm but regular rhythm for class 1.

AND 3. HR < 60 bpm.

AND 4. PR interval > 200 ms.

- **Sinus tachycardia with 1st degree AV block (010)**

a. True if the following conditions are met:
   1. One QRS class.

AND 2. Regular rhythm.

AND 3. HR > 100 bpm.

AND 4. PR interval > 200 ms.

OR b. True if the following conditions are met:
   1. Two QRS classes.

AND 2. Irregular rhythm for class 2 but regular rhythm for class 1.

AND 3. HR > 100 bpm.

AND 4. PR interval > 200 ms.

- **Slow atrial rhythm (011)**

a. One QRS class.
AND b. Regular rhythm.
AND c. 60 < HR < 100 bpm.
AND d. PR < 100 ms.
AND e. P wave detected in only one or two QRS complexes over the 10 second period.

- **Junctional rhythm, atrial fibrillation with AV block cannot be ruled out (013)**

a. One QRS class.
AND b. Regular rhythm.
AND c. PR interval null.
AND d. HR < 60 bpm.
AND e. Low probability of atrial fibrillation.

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- **Accelerated junctional rhythm (014)**

a. One QRS class.
AND b. Regular rhythm.
AND c. PR interval null.
AND d. 60 < HR < 100 bpm.
AND e. Low probability of atrial fibrillation.

- **Junctional tachycardia (015)**

a. True if the following conditions are met:
1. One QRS class.
AND 2. Regular rhythm.
AND 3. PR interval null.
AND 4. 100 < HR < 220 bpm.
AND 5. Low probability of atrial fibrillation.
OR b. True if the following conditions are met:
1. Two QRS classes.
AND 2. Irregular rhythm in class 2 but regular for class 1.
AND 3. PR interval null.
AND 4. HR > 100 bpm.

- **Accelerated idioventricular rhythm (017)**

Ventricular run or triplets detected with a rate < 100 bpm.

- **Ventricular or supraventricular tachycardia with aberrant conduction (018)**
  a. One QRS class.
  AND b. Regular rhythm.
  AND c. QRS duration > 124 ms.
  AND d. HR > 100 bpm.
  AND e. No P wave detected.

- **Sinus rhythm (019)**
  a. Atrial bigeminy, trigeminy or quadrigeminy detected.
  AND b. One QRS class.
  AND c. Regular rhythm.
  AND d. 60 < HR < 100 bpm.

- **Atrial flutter with 1:1 conduction (020)**
  a. Flutter detected.
  AND b. Regular rhythm.
  AND c. HR > 175 bpm.

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- **Atrial flutter with 2:1 conduction (021)**
  a. Flutter detected.
  AND b. Regular rhythm.
  AND c. 125 < HR < 175 bpm.

- **Atrial flutter with 3:1 conduction (022)**
  a. Flutter detected.
  AND b. Regular rhythm.
  AND c. 80 < HR < 125 bpm.

- **Atrial flutter with 4:1 conduction (023)**
  a. Flutter detected.
  AND b. Regular rhythm.
  AND c. 60 < HR < 80 bpm.

- **Atrial flutter with 5:1 conduction (024)**
  a. Flutter detected.
  AND b. Regular rhythm.
  AND c. HR < 60 bpm.

- **Atrial flutter with variable AV block (025)**
  a. Flutter detected.
  AND b. Irregular rhythm.

- **Atrial fibrillation (026)**
  a. QRS detected, no P wave, and irregular rhythm.
  OR b. One QRS class, PR interval not defined, and weak P wave.
  OR c. Atrial bigeminy (031), atrial trigeminy (032) or atrial quadrigeminy (083) detected.
  OR d. Two QRS classes, PR interval not defined, and irregular rhythm.
  OR e. One QRS class, regular rhythm, PR interval null, HR > 60 bpm, and high probability of atrial fibrillation.
  OR f. Two QRS classes, irregular rhythm, PR interval null, HR > 60 bpm, and high probability of atrial fibrillation.

- **Irregular rhythm with atrial extrasystole(s) (029)**
  Irregular rhythm with at least two short R intervals.

- **Sinus arrhythmia (030)**
  Irregular rhythm.

- **Atrial bigeminy (031)**
  a. One QRS class and bigeminy detected.
  OR b. Two QRS classes, no wide complex, and intermittent bigeminy detected.

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- **Atrial trigeminy (032)**
  a. One QRS class and trigeminy detected.
  OR b. Two QRS classes, no wide complex, and intermittent trigeminy detected.

- **Intermittent atrial bigeminy (033)**
  a. One QRS class and intermittent bigeminy detected.
  OR b. Two QRS classes, no wide complex, and intermittent trigeminy detected.

- **(Poorly defined P waves on averaged complexes) (034)**
  PR interval not defined.

- **Atrial fibrillation cannot be ruled out (035)**
  a. PR interval not defined and low probability of atrial fibrillation.
  OR b. Atrial bigeminy (031) or atrial trigeminy (032) detected, PR interval not defined, and low probability of atrial fibrillation.
  OR c. Mobitz (039), (040), (041), (042) or (043) detected, irregular rhythm, PR interval not defined, and low probability of atrial fibrillation.
  OR d. One QRS class, regular rhythm, PR interval null, and low probability of atrial fibrillation.

- **(Low voltage P waves on averaged complexes) (036)**
  The P wave on averaged beat is weak or undetectable.

- **Atrial ectopic beats (037)**
  a. Regular rhythm.
  AND b. Atrial ectopic beats detected.
  AND c. P wave negative in V1.

- **Atrial-ventricular dissociation between : (039)**
  Mobitz type I detected and HR > 45 bpm.

- **AV block (Mobitz type II) with 2:1 conduction (040)**
  Mobitz type II with 2:1 conduction detected.

- **AV block (Mobitz type I) Wenckebach phenomenon (041)**
  Mobitz type I detected and number of prolonged intervals > 0.

- **AV block (Mobitz type II) (042)**
  Mobitz type II detected.

- **AV block type III (043)**
  Mobitz type III detected and HR > 45 bpm.

- **Ventricular bigeminy (044)**
  a. Two QRS classes; one wide class and one narrow class.
  AND b. Bigeminy detected.

- **Ventricular trigeminy (045)**
  a. Two QRS classes; one wide class and one narrow class.
  AND b. Irregular rhythm and trigeminy detected.

- **Intermittent ventricular bigeminy (046)**
  a. Intermittent bigeminy detected, two QRS classes, and irregular rhythm.
  OR b. Two QRS classes; one wide class and one narrow class, and bigeminy detected.

- **(Wandering baseline!) (047)**
  The baseline is not flat enough.

- **Ventricular extrasystole(s) with bundle branch block (050)**
  a. Irregular rhythm.
  AND b. Two QRS classes, of which one is wide.
  AND c. Two short RR intervals detected.

- **Unifocal ventricular extrasystole(s) (052)**
  Two QRS classes and extrasystole(s) detected with the same morphology.

- **Multifocal ventricular extrasystole(s) (053)**
  Three QRS classes and extrasystole(s) detected with multiple morphology.

- **Atrial extrasystole(s) (055)**
  One QRS class several long intervals, and no run detected.

- **Ventricular extrasystole(s) (056)**
  a. Several QRS classes without bigeminy or trigeminy.
  OR b. Ventricular extrasystoles detected in bigeminy or trigeminy.
  OR c. Two QRS classes and extrasystole(s) detected.

- **Interpolated ventricular extrasystole(s) (057)**
  Two QRS classes, extrasystoles detected, and normal interval before and after the extrasystoles.

- **Ventricular extrasystole(s) with full compensation (058)**
  Two QRS classes, extrasystoles detected, and long interval after the extrasystoles.

- **Ventricular extrasystole(s) without full compensation (059)**
  Two QRS classes, extrasystoles detected, and normal interval after the extrasystoles.

- **Supraventricular extrasystole(s) (060)**
  One QRS class, extrasystoles detected, several long intervals, and supraventricular extrasystoles detected between the RR intervals.

- **Ventricular couplets (068)**
  Two QRS classes, several long intervals, and couplet detected (two ectopic beats in succession).

- **Ventricular triplets (069)**
  Two QRS classes, several long intervals, and triplet detected (three ectopic beats in succession).

- **Run of ventricular extrasystoles (070)**
  Two QRS classes, several long intervals, and run detected (more than three ectopic beats in succession).

- **Atrial couplets (071)**
  One QRS class, several long intervals, and couplet detected (two ectopic beats in succession).

- **Atrial triplets (072)**
  One QRS class, several long intervals, and triplet detected (three ectopic beats in succession).

- **Run of atrial extrasystoles (073)**
  One QRS class, several long intervals, and run detected (more than three ectopic beats in succession).

- **Atrial flutter with a variable block cannot be ruled out (075)**
  Flutter detected with low risk and irregular rhythm.

- **(False beat excluded) (076)**
  An incorrect beat has been detected caused probably by noise. This beat has been rejected for the analysis.

- **Very low flutter probability (078)**
  Possible flutter detected with very low probability.

- **Atrial pacing (079)**
  Spikes are present before each QRS.

- **Sinus arrhythmia with 1st degree AV block (080)**
  Irregular rhythm and PR interval > 100 ms.

- **Pacing??? (082)**
  Spikes are present but the software does not recognize the type of pacemaker.

- **Atrial quadrigeminy (083)**
  a. One QRS class and quadrigeminy detected.
  OR b. Two QRS classes, not too wide, and quadrigeminy detected.

- **Ventricular quadrigeminy (084)**
  Two QRS classes, one wide class, and quadrigeminy detected.

- **AV block type I (085)**
  Regular rhythm and PR interval > 100 ms.

- **Extreme bradycardia (086)**
  Regular rhythm and HR < 45 bpm.

- **Idioventricular rhythm (087)**
  a. One QRS class.
  AND b. Regular rhythm.
  AND c. QRS duration > 124 ms.
  AND d. HR < 100 bpm.
  AND e. No P wave detected.

CHAPTER 3 - MORPHOLOGY CRITERIA

Lead Reversal / Dextrocardia

Note: If one of these conditions is detected no further analysis is performed.

- **Inverted limb electrodes (089)**

  True if the following conditions are met:

  a. Q wave present in I (Q*(I) > 12 ms.).
  AND b. QRS duration < 110 ms.
  AND c. P wave negative in Lead I.
  AND d. S(I) > (R(I) + 0.2 mV).
  AND e. R(V1) or R(V2) > (S(V1) + 0.3 mV) or (S(V2) + 0.3 mV).
  AND f. R(V1) or R(V2) > R(V5).

- **Congenital dextrocardia (090)**

  True if the following conditions are met:

  a. Q wave present in I (Q*(I) > 12 ms.).
  AND b. QRS duration < 110 ms.
  AND c. P wave negative in Lead I.
  AND d. S(I) > (R(I) + 0.2 mV).

Atrial Hypertrophy

Left Atrial Hypertrophy

- **Possible left atrial hypertrophy (092)**

  a. Terminal surface of P in V1 > 0.04 mm/s
  AND b. P(V1) < 1 mm.

- **Left atrial hypertrophy (091)**

  a. Terminal surface of P in V1 > 0.04 mm/s
  AND b. P axis ≤ -15°
  AND c. P duration > 110 ms

Right Atrial Hypertrophy

- **Possible right atrial hypertrophy (096)**
  True if one of the following conditions is met:
  a. P(II) > 0.25 mV or P′(II) > 0.25 mV.
  OR b. P(III) > 0.25 mV or P′(III) > 0.25 mV.
  OR c. P(aVF) > 0.25 mV or P′(aVF) > 0.25 mV.
  OR d. P axis > 75°.

- **Right atrial hypertrophy (095)**
  True if any three of the following conditions are met:
  a. P(II) > 0.25 mV or P′(II) > 0.25 mV.
  b. P(III) > 0.25 mV or P′(III) > 0.25 mV.
  c. P(aVF) > 0.25 mV or P′(aVF) > 0.25 mV.
  d. P axis > 75°.

Biatrial Hypertrophy

- **Possible biatrial hypertrophy (099)**
  a. Possible left atrial hypertrophy (092).
  AND b. Possible right atrial hypertrophy (096).

- **Biatrial hypertrophy (098)**
  a. Right atrial hypertrophy (095) or left atrial hypertrophy (091).
  AND b. Possible right atrial hypertrophy (096) or Possible left atrial hypertrophy (092).

Ventricular Pre-Excitation

Note: If ventricular pre-excitation is detected no further analysis is performed.

- **Wolff-Parkinson-White syndrome (104)**
  Delta waves in at least three of the 12 leads.

- **Wolff-Parkinson-White syndrome (type A) (102)**
  a. R(V1) > S(V1).
  AND b. Delta waves in at least three leads.
  AND c. P-R interval < 120 ms.

AND d. No atrial fibrillation.

- **Wolff-Parkinson-White syndrome (type B) (103)**
  a. R(V1) < S(V1).
AND b. Delta waves in at least three leads.
AND c. P-R interval < 120 ms.
AND d. No atrial fibrillation.

- **Ventricular pre-excitation syndrome cannot be ruled out (105)**
  a. Delta waves in at least two leads.
AND b. P-R interval < 100 ms.

QRS Abnormalities

Abnormal QRS Amplitude

- **Low QRS voltages (109)**
  a. Maximum amplitude of < 0.5 mV. in two of the limb leads.
AND b. Maximum amplitude of < 1 mV in four of the precordial leads.

- **Voltage beyond the criteria for left ventricular hypertrophy, may be normal variant by the weight (093)**
  a. R(aVL) >= 1.2mV.
OR b. R(I) or R(II) >= 1.5mV.
OR c. (R(III) > 2mV) or (S(III) > 1.2mV).
OR d. R(aVF) > 2mV.
OR e. (S(V1) > 2.2mV) or (S(V2) > 2.5mV).
OR f. (R(V3) > 2mV) or (S(V3) > 2.2mV).
OR g. (R(V4) > 2mV) or (S(V4) > 1.7mV).
OR h. (R(V5) > 2.2mV) or (R(V6) > 2mV).
OR i. (R(V5) + S(V1)) > 3.5mV for women or > 4mV for men.
OR j. (R(V6) + S(V1)) > 3.5mV for women or > 4mV for men.

Note: If one of the above conditions occurs in a proportion of at least 90%, this criteria applies; if a LBBB is present this criteria does not apply.

Abnormal QRS Duration

Note: The following statements are calculated only in the absence of LBBB or RBBB.

- **Non systematic minor intraventricular block (118)**
  115 ms < QRS duration ≤ 130 ms.

- **Non systematic major intraventricular block (117)**
  QRS duration > 130 ms.

Abnormal Axis

- **Right QRS axis deviation (123)**
  QRS Axis ≥ 130°

- **Left QRS axis deviation (124)**
  QRS Axis ≤ -30°

Positional Variance Of The Precordials

- **Premature QRS transition in right precordials, positional variance (128)**
  a. R/S > 1 in V1 or V2.
  AND b. No posterior myocardial infarction and no inferior myocardial infarction or presence of right ventricular hypertrophy.

- **Late QRS transition in left precordials, positional variance (130)**
  a. R/S < 1 in V4 or V5.
  AND b. Neither infarction nor left ventricular hypertrophy are present.

Bundle Branch Blocks

- **Incomplete left bundle branch block (112)**
  True if QRS duration > 100 ms and any four of the following conditions are met:
  a. S(V1) wave > 3 x R(V1) wave and S(V2) wave > 3 x R(V2) wave.
  b. Two of the following conditions are met:
     1. R*(I) > 80 ms.
     2. R*(V5) > 80 ms.
     3. R*(V6) > 80 ms.
  c. Two of the following conditions are met:
     1. Q(I) < 1 mm.
     2. Q(V5) < 1 mm.
     3. Q(V6) < 1 mm.
  d. T(V5) < -1 mm or T(V6) < -1 mm.
  e. Delayed intrinsicoid deflection in V5 and V6.

- **Complete left bundle branch block (110)**
  True if QRS duration > 120 ms and any four of the following conditions are met:
  a. (S(V1) > 3 x R(V1)) and (S(V2) > 3 x R(V2)).
  b. True if two of the following conditions are met:
     1. R*(I) > 80 ms.
     2. R*(V5) > 80 ms.
     3. R*(V6) > 80 ms.
  c. True if two of the following conditions are met:
     1. Q(I) < 1 mm.
     2. Q(V5) < 1 mm.
     3. Q(V6) < 1 mm.
  d. T(V5) < -1 mm or T(V6) < -1 mm.
  e. Delayed intrinsicoid deflection in V5 and V6.

- **Atypical complete left bundle branch block (111)**

  True if the QRS duration > 100 ms and the following conditions are met:

  a. (S(V1) > 3 x R(V1)) and (S(V2) > 3 x R(V2)).

  AND b. Two of the following conditions are met:

  1. R*(I) > 80 ms.
  2. R*(V5) > 80 ms.
  3. R*(V6) > 80 ms are present.

  AND c. Two of the following conditions are met:

  1. Q(I) < 1 mm.
  2. Q(V5) < 1 mm.
  3. Q(V6) < 1 mm.

- **Possibly with left ventricular hypertrophy (113)**

  True if (110) or (111) are detected and the following conditions are met:

  a. (R(V6) + S(V1) > 45 mm) or (R(V6) + S(V2) > 45 mm).

  AND b. QRS duration > 140 ms.

- **Incomplete right bundle branch block (116)**

  True if QRS duration > 100 ms and any three of the following conditions are met:

  a. True if the following conditions are met:

  1. R*(aVR) > 60 ms.

  OR 2. R*(V1) > 60 ms.

  OR 3. R*(aVR) > 60 ms.

  OR 4. R*(V1) > 60ms.

  b. True if the following conditions are met:

  1. T(aVR) < -1 mm.

  OR 2. T(V1) < -1 mm.

  c. Delayed intrinsicoid deflection in V1 and V2.

  d. Two of the following conditions are met.

  1. S*(I) > 60 ms.
  2. S*(V5) > 60 ms.
  3. S*(V6) > 60 ms.

- **Complete right bundle branch block (114)**

  True if QRS duration > 120 ms and any three of the following conditions are met:

  a. True if the following conditions are met:
     1. R*(aVR) > 60 ms.

  OR 2. R*(V1) > 60 ms.

  OR 3. R*(aVR) > 60 ms.

  OR 4. R*(V1) > 60ms.

  b. True if the following conditions are met:
     1. T(aVR) < -1 mm.

  OR 2. T(V1) <-1 mm.

  c. Delayed intrinsicoid deflection in V1 and V2.

  d. True if two of the following conditions are met:
     1. S*(I) > 60 ms.
     2. S*(V5) > 60 ms.
     3. S*(V6) > 60 ms.

- **Compatible with a bundle branch block (131)**

  True if the following conditions are met:

  a. QRS duration > 95 ms.

  AND b. No left bundle branch block.

  AND c. (R(V1) > 1 mm) and (R′(V1) > 1 mm).

- **Atypical complete right bundle branch block (115)**

  True if the following conditions are met:

  a. QRS duration > 120 ms.

  AND b. True if any two of the following conditions are met:
     1. S*(I) > 60 ms.
     2. S*(V5) > 60 ms.
     3. S*(V6) > 60 ms.

- **RSR' in V1, could be normal (280)**

  True if the following conditions are met:

  a. QRS duration > 90 ms.

  AND b. No left bundle branch block.

  AND c. True if any one of the following conditions is met:
     1. (R(aVR) > 1 mm) and (R′(aVR) > 1 mm).

  OR 2. (R(V1) > 1 mm) and (R′(V1) > 1 mm).

- **Possible left anterior fascicular block (120)**

  True if the following conditions are met:

  a. QRS duration < 110 ms.

  AND b. -30° > QRS axis > -45°.

  AND c. Three of the following conditions are met:

  1. (S*(II) > 30 ms) or (S′*(II) > 30 ms).
  2. (S*(III) > 30 ms) or (S′*(III) > 30 ms).
  3. (S*(V5) > 30 ms) or (S′*(V5) > 30 ms).
  4. (S*(V6) > 30 ms) or (S′*(V6) > 30 ms).

  AND d. (Q*(I) > 12 ms) and (Q*(aVL) > 12 ms).

- **Left anterior fascicular block (119)**

  True if the following conditions are met:

  a. QRS duration < 120 ms.

  AND b. -45° > QRS axis > -90°.

  AND c. True if any three of the following conditions are met:

  1. (S*(II) > 30 ms) or (S′*(II) > 30 ms).
  2. (S*(III) > 30 ms) or (S′*(III) > 30 ms).
  3. (S*(V5) > 30 ms) or (S′*(V5) > 30 ms).
  4. (S*(V6) > 30 ms) or (S′*(V6) > 30 ms).

- **Possible bifascicular block (125)**

  a. Left bundle branch block (110) or right bundle branch block is detected (114).

  b. (119) or (120) is detected.

- **Left posterior fascicular block (122)**

  a. QRS duration < 110 ms.

  AND b. 110° < QRS axis < 180°.

  AND c. S*(I) > 12 ms.

  AND d. Q*(III) > 12 ms.

- **Left posterior fascicular block cannot be ruled out (127)**

  Note: Does not apply if woman < 35 years or lightweight woman.

  a. QRS duration < 110 ms.

  AND b. QRS axis > 90°.

  AND c. S*(I) > 12 ms.

  AND d. Q*(III) > 12 ms.

- **Bifascicular block (126)**

  Note: This statement replaces the other block statements.

  True if right bundle branch block is detected and one of the following conditions is met:

  a. Left anterior fascicular block (119) is detected.

  OR b. Possible left anterior fascicular block (120) is detected.

  OR c. Left posterior fascicular block (122) is detected.

  OR d. True if right bundle branch block is detected and the following conditions are met:

  1. -30° > QRS axis > -100°

  AND 2. True if three of the following conditions are met:

  (i). (S*(II) > 30 ms) or (S′*(II) > 30 ms).

  (ii). (S*(III) > 30 ms) or (S′*(III) > 30 ms).

  (iii). (S*(V5) > 30 ms) or (S′*(V5) > 30 ms).

  (iv). (S*(V6) > 30 ms) or (S′*(V6) > 30 ms).

Ventricular Hypertrophy

Right Ventricular Hypertrophy

Note: If left or right bundle branch block as been detected this section is omitted.

Criteria:

A. True if any three of the following conditions are met:
   1. R(V1) + S(V5 or V6) > 10.5 mm.
   2. R/S Ratio in V5 or V6 < 1.
   3. S(V5 or V6) > 7 mm.
   4. R(V5 or V6) < 5mm.

B. QRS axis > 110°.

C. T < -1 mm in two of V1, V2 or V3.

D. ST ≤ -1mm in two of V1, V2 or V3.

E. > 100 ms QRS duration < 120 ms.

- **Right ventricular hypertrophy with wide QRS and secondary abnormal repolarisation, possibly right ventricular strain (155)**

  True if A (three out of four), B, C, D, and E are true.

- **Right ventricular hypertrophy with secondary abnormal repolarisation, possibly right ventricular strain (156)**
  True if A (three out of four), B, C, and D are true.

- **Right ventricular hypertrophy with wide QRS and secondary abnormal repolarisation (157)**
  True if A (three out of four), B, C, D, and E are true.

- **Right ventricular hypertrophy with secondary abnormal repolarisation (158)**
  True if A (three out of four), B, and C are true.

- **Right ventricular hypertrophy with wide QRS (159)**
  True if A (three out of four), B, and E are true.

- **Right ventricular hypertrophy (160)**
  True if A (three out of four) and B are true.

- **Possible right ventricular hypertrophy (161)**
  a. Any two of the following conditions are met:
     1. R(V1) + S(V5 or V6) > 10.5 mm.
     2. R/S Ratio in V5 or V6 < 1.
     3. S(V5 or V6) > 7 mm.
     4. R(V5 or V6) < 5 mm.

AND b. QRS axis > 90°.

- **Right ventricular hypertrophy cannot be ruled out (162)**
  a. True if the following conditions are met:
     1. Right bundle branch block detected.

AND 2. QRS axis > 120°.

OR b. True if the following conditions are met:
     1. Right bundle branch block detected.

AND 2. Right atrial hypertrophy detected.

AND 3. QRS axis > 90°.

Left Ventricular Hypertrophy

Note: If left bundle branch block has been detected this section is omitted.

Criteria:

A. S(V1 or V2) + R(V5 or V6) ≥ the following limit:

	Age < 30	Age > 30
Lightweight	4.9 mV	3.9 mV
Normal	4.8 mV	3.8 mV
Overweight	4.7 mV	3.7 mV

B. (R(I) – R(III)) + (S(III) + S(I))) ≥ the following limit:

Lightweight	2.0 mV
Normal	1.9 mV
Overweight	0.8 mV

C. Score ≥ 5 points from the following tests:

3 points if any one of the following conditions are met :

1. R(V5 or V6) > 3 mV.
2. S(V1 or V2) > 3 mV.
3. R(I or aVL) > 2 mV.

2 points if ST < 1 mm in four of leads I, aVL, V4, V5, V6 and T < 3 mm (or 5 mm) in four of leads I, aVL, V4, V5, V6.

1 point if QRS axis ≥ -30°.

1 point if left atrial hypertrophy detected.

1 point if QRS duration > 100 ms.

D. T < -2 mm in two of the three leads V4, V5, and V6.

E. ST ≤ -1 mm in two of the three leads V4, V5, and V6.

F. > 100 ms QRS duration < 120 ms.

- **Left ventricular hypertrophy with wide QRS, secondary abnormal repolarisation, possibly left ventricular strain (145)**
  True if any one of A, B, or C is true and D, E, and F are true.

- **Left ventricular hypertrophy with secondary abnormal repolarisation, possibly left ventricular strain (146)**
  True if any one of A, B, or C is true and D and E are true.

- **Left ventricular hypertrophy with wide QRS and secondary abnormal repolarisation (147)**
  True if any one of A, B, or C is true and D and F are true.

- **Left ventricular hypertrophy with secondary abnormal repolarisation (148)**
  True if any one of A, B, or C is true and D is true.

- **Left ventricular hypertrophy with wide QRS (149)**
  True if any one of A, B, or C is true and F is true.

- **Left ventricular hypertrophy (150)**
  True if any one of A, B, or C is true.

Biventricular Hypertrophy

- **Biventricular hypertrophy with wide QRS and abnormal secondary repolarisation, possible left ventricular strain (135)**
  True if (145) and (155) are detected.

- **Biventricular hypertrophy with secondary abnormal repolarisation, possible left ventricular strain (136)**
  True if (146) and (156) are detected.

- **Biventricular hypertrophy with wide QRS and secondary abnormal repolarisation, possible right ventricular strain (137)**
  True if (147) and (157) are detected.

- **Biventricular hypertrophy with secondary abnormal repolarisation, possible right ventricular strain (138)**
  True if (148) and (158) are detected.

- **Biventricular hypertrophy with wide QRS and secondary abnormal repolarisation (139)**
  True if (149) and (159) are detected.

- **Biventricular hypertrophy with secondary abnormal repolarisation (140)**
  True if (150) and (160) are detected.

- **Biventricular hypertrophy with wide QRS (141)**
  True if (151) and (161) are detected.

- **Biventricular hypertrophy (142)**
  True if (152) and (162) are detected.

Infarction

Test 1: Q wave detected if:

1. Q length >= 40ms.
2. (3 x amplitude of Q) > amplitude R, and amplitude of Q >= 0.150 mV.
3. The following three conditions are met (QS aspect):
   a. Length Q < 15 ms and amplitude of Q < 0.07 mV.

AND b. Length R < 15 ms and amplitude of R < 0.07 mV.

AND c. Length S > 40 ms and length S' < 15 ms.

Specific test for the aVL lead:

1. Q length >= 40ms.
2. (2 x amplitude of Q) > amplitude R, and amplitude of Q >= 0.150 mV.
3. Amplitude of Q > 0.150 mV.

Specific test for the aVF lead:

1. Q length >= 40ms.
2. (3 x amplitude of Q) > amplitude R, and amplitude of Q >= 0.150 mV.
3. If (Q amplitude + R amplitude) < 0.200 mV and no Q wave detected.

Test 2 for aVF:

1. 12 ms < Q(aVF) < 30 ms.
2. Q(aVF) > 0.150 mV.
3. ((3 x Q(aVF)) > (R(aVF)) and ((4 x Q(aVF)) < R(aVF)).

Inferior Infarction

Note: If left bundle branch block has been detected this section is omitted.

Criteria:

A. Q wave detected in Lead II (test 1).
B. Q wave detected in Lead III (test 1).
C. Q wave detected in aVF (test 1).

- **Inferior infarction, probably acute (171)**

a. A is true and either B or C is true.
AND b. J point is altered a minimum of 0.200 mV in two of three lead II, III or aVF.

- **Inferior infarction, probably recent or with ventricular aneurysm (172)**

a. A is true and either B or C is true.
AND b. ST segment is altered a minimum of 0.200 mV in two of three lead II, III or aVF.

- **Inferior infarction, probably old (173)**

True if the following conditions are met:

a. A is true.
AND b. True if the following conditions are met:
1. B is true.
OR 2. C is true or Test 2 for aVF is met.
AND c. T wave negative and > than 0.05 mV in two of three leads II, III or aVF.
AND d. Any two of the following conditions are met:
1. Q(II) > 2 x R(II).
2. Q(III) > 2 x R(III).
3. Q(aVF) > 2 x R(aVF).

- **Possible inferior infarction, probably old (175)**

a. Q wave detected in Lead II or (Q wave detected in Lead III and aVF).
OR b. Test 2 for aVF is met.

- **Possibly associated with lateral extension (177)**
  a. Inferior Infarct detected.
  OR b. Q wave present in V5.
  OR c. Q wave present in V6.

- **Possible posterior infarction (187)**
  a. R(V1) > 0.700 mV.
  AND b. (3 x R(V1)) > (2 x S(V1)).
  AND c. 0 < T(V1) < 0.700 mV.
  AND d. QRS axes < 130°.
  AND e. R*(V1) > 50 ms.

- **Posterior infarction cannot be ruled out (188)**
  a. R(V1) > 0.700 mV.
  AND b. (3 x R(V1)) > (2 x S(V1)).
  AND c. T(V1) > 0.700 mV.
  AND d. QRS axes < 130°.
  AND e. R*(V1) > 50 ms.

- **Associated with a peri-infarction block (190)**
  a. Inferior infarct is detected.
  AND b. 110ms < QRS duration <= 130ms and without RBBB or LBBB.

- **Inferoposterior infarction, probably acute (181)**
  a. (171) is detected.
  AND b. (187) is detected.

- **Inferoposterior infarction, probably recent or with ventricular aneurysm (182)**
  a. (172) is detected.
  AND b. (187) is detected.

- **Inferoposterior infarction, probably old (183)**
  a. (173) is detected.
  AND b. (187) is detected.

- **Possible inferoposterior infarction, probably old (184)**
  a. (173) is detected.
  AND b. (188) is detected.

- **Inferoposterior infarction cannot be ruled out (185)**
  a. (175) is detected.
  AND b. (188) is detected.

- **Anteroseptal infarction, probably acute (191)**
  True if J point is altered a minimum of 0.200 mV in lead V1 or V2 and the first two conditions are met or the third:
  a. Q wave detected in V1 (test 1).
  b. Q wave detected in V2 (test 1).
  c. Q wave detected in V2 (test 1) and (2 x R(V1) < S(V1)) (RS aspect).

- **Anteroseptal infarction, probably recent or with ventricular aneurysm (192)**
  True if ST segment is altered in lead V1 or V2 and the first two conditions are met or the third:
  a. Q wave detected in V1 (test 1).
  b. Q wave detected in V2 (test 1).
  c. Q wave detected in V2 (test 1) and (2 x R(V1) < S(V1)) (RS aspect).

- **Anteroseptal infarction, probably old (193)**
  True if T wave is negative more than 0.05 mV in lead V1 or V2 and the first two conditions are met or the third:
  a. Q wave detected in V1 (test 1).
  b. Q wave detected in V2 (test 1).
  c. Q wave detected in V2 (test 1) and (2 x R(V1) < S(V1)) (RS aspect).

- **Possible anteroseptal infarction, probably old (195)**
  True if no repolarisation troubles in lead V1 or V2 and the first two conditions are met or the third:
  a. Q wave detected in V1 (test 1).
  b. Q wave detected in V2 (test 1).
  c. Q wave detected in V2 (test 1) and (2 x R(V1) < S(V1)) (RS aspect).

Anterior Infarction

- **Anterior infarction, probably acute (201)**
  True if J point is altered a minimum of 0.200 mV in two of V2, V3 or V4 and two of following conditions are met:
  a. Q wave detected in V2 (test 1).
  b. Q wave detected in V3 (test 1).
  c. Q wave detected in V4 (test 1).

- **Anterior infarction, probably recent or with ventricular aneurysm (202)**
  True if ST segment is altered in two of V2, V3 or V4 and two of following conditions are met:
  a. Q wave detected in V2 (test 1).
  b. Q wave detected in V3 (test 1).
  c. Q wave detected in V4 (test 1).

- **Anterior infarction, probably old (203)**
  True if T wave is negative > 0.05 mV in two of V2, V3 or V4 and two of following conditions are met:
  a. Q wave detected in V2 (test 1).
  b. Q wave detected in V3 (test 1).
  c. Q wave detected in V4 (test 1).

- **Possible anterior infarction, probably old (205)**
  True if no repolarisation troubles in V2, V3 or V4 and two of following conditions are met:
  a. Q wave detected in V2 (test 1).
  b. Q wave detected in V3 (test 1).
  c. Q wave detected in V4 (test 1).

Lateral Infarction

Criteria:

A. Q wave present in lead I:
   1. Q duration > 40 ms.
   2. Q amplitude x 2 > R amplitude.
   3. Q amplitude > 150 mV.

B. Q wave present in aVL:
   1. Q amplitude < 10 mV and R amplitude < 70 mV
      and S′ amplitude < 10 mV
      and S* > 40 ms.
   2. Q* > 40 ms.
   3. Q amplitude > 150 mV and (Q amplitude x 3 > R amplitude).
   4. Q* < 15 ms and Q amplitude < 70 mV
      and R* < 15 ms
      and R amplitude < 70 mV
      and S′ amplitude < 10 mV
      and S* > 40 ms.

- **Lateral infarction, probably acute (211)**
  a. Three conditions of A are met.
  AND b. One condition of B is met.
  AND c. ST elevation > 250 mV in lead I or aVL.

- **Lateral infarction, probably recent or with ventricular aneurysm (212)**
  a. Three conditions of A are met.
  AND b. One condition of B is met.
  AND c. ST elevation > 100 mV in lead I or aVL.

- **Lateral infarction, probably old (213)**
  a. Three conditions of A are met.
  AND b. One condition of B is met.

Possible Lateral Infarction

Criteria:

A. Q wave present in lead I:
   1. Q duration > 20 ms.
   2. Q amplitude x 3 > R amplitude.
   3. Q amplitude > 150 mV.

B. Q wave present in aVL:
   1. Q duration > 20 ms.
   2. Q amplitude x 3 > R amplitude.
   3. Q amplitude > 150 mV.
   4. R amplitude < 1200 mV.
   5. S Amplitude < 1200 mV.

- **Possible lateral infarction, probably recent or with ventricular aneurysm (214)**
  a. Three conditions of A are met.
  AND b. Five conditions of B are met.
  AND c. ST elevation > 100 mV in lead I or aVL.

- **Possible lateral infarction, probably old (215)**
  a. Three conditions of A are met.
  AND b. Five conditions of B are met.

- **Lateral infarction cannot be ruled out (216)**
  True if the conditions of A and B are met.

- **Widespread anterior infarction, probably old (223)**
  True if the following conditions are met:
  a. One of (191), (193) or (195) is detected.
  AND b. One of (201), (202), (203) or (205) is detected.
  AND c. One of (211), (212), (213) or (215) is detected or Q*(V5) > 15ms.

- **Widespread anterior infarction, probably acute (221)**

  True if the following conditions are met:

  a. True if the following conditions are met:

  1. (223) is true.

  AND 2. ST segment elevation > 0.2 mV in V2, V3, V4 or V5.

  OR b. True if the following conditions are met:

  1. (201) is detected.

  AND 2. Q wave detected in lead I.

  AND 3. Q wave detected in aVL.

- **Widespread anterior infarction, probably recent or with ventricular aneurysm (222)**

  True if the following conditions are met:

  a. True if the following conditions are met:

  1. (223) is detected.

  AND 2. ST segment elevation > 0.1 mV in V2, V3, V4 or V5.

  OR b. True if the following conditions are met:

  1. (201) is detected.

  AND 2. Q wave detected in lead I.

  AND 3. Q wave detected in aVL.

- **Anterolateral infarction, probably old (219)**

  True if the following conditions are met:

  a. True if the following conditions are met:

  1. One of (203) or (205) is detected

  OR 2. Q(V3) > 0.15 mV.

  AND b. One of (213), (215) or (216) is detected.

- **Anterolateral infarction, probably acute (217)**

  a. (219) is detected.

  AND b. ST segment elevation > 0.2 mV in V3, V4, V5 or V6.

- **Anterolateral infarction, probably recent or with ventricular aneureysm (218)**

  a. (219) is true.

  AND b. ST segment elevation > 0.1 mV in V3, V4, V5 or V6.

Atypical Q Wave

Note: These criteria are only applicable if no infarction is detected.
Criteria:

A. Q wave in lead III > 0.35 mV.
B. Q wave in lead II > 0.2 mV.
C. Q wave in aVF > 0.3 mV.

- **Inferior infarction cannot be ruled out (176)**
  True if Q wave detected in lead III and A, B, and C are true.

- **Atypical Q wave in lead III (169)**
  True if Q wave detected in lead III and A is true.

- **Insignificant Q wave in high lateral (168)**
  a. Q wave in lead I > 0.2 mV.
  AND b. Q wave in aVL > 0.2 mV.

Repolarisation Troubles

Criteria:
The detection tests of the following repolarisation troubles are not realized if:

A. A right or left bundle branch block is already detected.
OR B. hypertrophy with secondary repolarisation troubles is already detected.

- **Ischemic ST-T changes compatible with epicardial injury in inferior leads (231)**
  a. ST elevation > 0.1 mV in two of leads II, III or aVF.
  AND b. A and B are true.

- **Ischemic ST-T changes compatible with epicardial injury in lateral leads (232)**
  a. ST elevation > 0.1 mV in three of leads I, aVL, V5 or V6.
  AND b. A and B are true.

- **Ischemic ST-T changes compatible with epicardial injury in anterior leads (233)**
  a. ST elevation > 0.1 mV in three of V1, V2, V3 or V4.
  AND b. A and B are true.

- **Ischemic ST-T changes compatible with epicardial injury in anterolateral leads (229)**
  a. (232) and (233) are detected.
  AND b. A and B are true.

- **Ischemic ST-T changes in posterior leads (239)**
  Negative T wave > -0.1 mV in V1 and V2.

- **Ischemic ST-T changes in inferior leads (241)**
  Negative T wave > -0.1 mV in two of leads II, III or aVF.

- **Ischemic ST-T changes in lateral leads (242)**
  Negative T wave > -0.1 mV in three of leads I, aVL, V5 or V6.

- **Ischemic ST-T changes in anterior leads (243)**
  Negative T wave > -0.1 mV in three of V1, V2, V3 or V4.

- **Ischemic ST-T changes in anterolateral leads (244)**
  True if (242) and (243) are detected.

- **Ischemic ST-T changes posterolateral leads (236)**
  True if (239) and (242) are detected.

- **Ischemic ST-T changes in inferoposterolateral leads (237)**
  True if (239), (241), and (242) are detected.

- **Ischemic ST-T changes in inferoposterior leads (238)**
  True if (239) and (241) are detected.

- **Ischemic ST-T changes compatible with subendocardial injury in inferoapical leads (261)**
  True if horizontal or negative slope ST segment depression > -0.1 mV in two of leads II, III or aVF.

- **Ischemic ST-T changes compatible with subendocardial injury in lateral leads (262)**
  True if horizontal or negative slope ST segment depression > -0.1 mV in two of leads I, aVL, V5 or V6.

- **Ischemic ST-T changes compatible with subendocardial injury in anterior leads (263)**
  True if horizontal or negative slope ST segment depression > -0.1 mV in two of V1, V2, V3 or V4.

- **Ischemic ST-T changes compatible with subendocardial injury in anterolateral leads (264)**
  True if (262) and (263) are detected.

- **Abnormal repolarisation, may be due to digitalis effect (271)**
  True if ST segment depression with negative slope with a negative T-wave in five or more leads.

- **Widespread abnormal repolarisation, pericarditis cannot be ruled out (272)**
  True if ST elevation > 0.1 mV with a negative T wave or terminal point of T wave < -0.05 mV in six or more leads.

- **Abnormal repolarisation, may be electrolytic unbalance (273)**
  True if T wave amplitude > 0.5 mV in eight or more leads.

- **Abnormal repolarisation, possibly non-specific (274)**
  a. Dominant R or R′ in the QRS complex and a negative T wave of < 0.1 mV in four or more leads.

  AND b. No infarction or ventricular hypertrophy or other abnormal ST-T detected.

- **Abnormal repolarisation, possible coronaric ischemia (275)**

a. Dominant R or R′ in the QRS complex and a negative T wave of < 0.1 mV in four or more leads.

AND b. no infarction or ventricular hypertrophy or other abnormal ST-T detected in men age ≥ 50 or women age ≥ 55.

Normal Trace

- **Poor R Progression in right precordial leads (279)**

a. No abnormalities detected.

AND b. R(V1) < 0.2 mV.

AND c. R(V1) > R(V2) and R(V2) > R(V3).

OR

a. No abnormalities detected.

AND b. R(V1) < 0.2 mV.

AND c. R(V1) < R(V2) and R(V2) > R(V3).

- **RSR' in V1 could be normal (280)**

RSR' with R' > R.

- **Prolonged QT interval (284)**

QTc > 450 ms.

- **Short PR interval (106)**

PR < 120 ms.

- **QRS within the normal limits (282)**

True if the following conditions are true:

a. One of (91), (92), (95), (96), (97), (98), (99), (106), (109), (118), (123), (124), (128), (130), (276) or (284) is detected.

AND b. No other abnormalities are detected.

- **Normal morphology (283)**

No abnormalities are detected.

CHAPTER 4 - ECG ANALYSIS PERFORMANCE AND ACCURACY

The ECG analysis program is a software component that provides analysis and interpretation of 12 lead ECGs. The ECG analysis program was developed and tested by Cardionics SA in conjunction with the Université Catholique de LOUVAIN (UCL). The ECG analysis program has also been independently evaluated by the Common Standards for Quantitative Electrocardiography (CSE) Coordinating Centre.

Standard formulas in which TP represents a true positive result, FN a false negative result, TN a true negative result, and FP a false positive result, were used to calculate sensitivity (TP/[TP+FN]), specificity (TN/[TN+FP]), positive predictive value (TP/[TP+FP]), and negative predictive value (TN/[TN+FN]). Prevalence is defined as the ratio of the number of occurrences of a particular condition to the total number of cases in the database.

Note: Modifications may be made to this interpretive program from time to time which could affect these results.

Performance Results

A. CSE Database

The CSE database contains 1220 clinically validated cases with type A diagnosis, which have been determined from non-electrocardiographic evidence. The following table represents the statistical accuracy of the ECG analysis program.

Table 1. Statistical accuracy of the ECG analysis program

Cardiac Disorder	**Sensitivity**	**Specificity**	**Positive Predictive Value**	**Negative Predictive Value**	**Prevalence**
Normal	90.1	82.6	70.2	94.8	382/1220
Left Ventricular Hypertrophy	53.0	97.3	77.9	92.1	183/1220
Right Ventricular Hypertrophy	39.7	98.6	57.8	97.2	55/1220
Biventricular Hypertrophy	34.0	99.4	72.7	97.1	53/1220
Anterior Myocardial Infarction	82.0	94.5	70.6	97.0	170/1220
Inferior Myocardial Infarction	72.9	97.4	88.9	92.6	273/1220
Combined Myocardial Infarction	68.0	98.3	71.6	98.0	73/1220
Combined Infarction and Hypertrophy	52.0	100.0	100.0	98.8	31/1220
Total Hypertrophy	50.0	95.9	77.2	87.1	291/1220
Total Myocardial Infarction (Includes Combined Infarction and Hypertrophy)	76.8	87.2	83.0	82.2	547/1220

These results were officially presented at the XXI international congress on electrocardiology in Yokohama in July 1994.

B. Cardionics/UCL Morphology Database

The Cardionics/UCL morphology database of ECGs consist of 4700 cases with type A diagnosis, which have been determined from non-electrocardiographic evidence, and type B diagnosis, which have been determined primarily from the ECG itself. Type B diagnoses were determined by a cardiologist at the UCL Hospital. Statements produced by the ECG analysis program were mapped onto diagnostic codes following the CSE coding scheme, where a code comprises of a diagnostic category and one of three qualifiers: definite (A), probable (B), or possible (C). The mapping of statements generated by CardioView3000 to CSE codes is listed in Table 4.

Table 2. Statistical accuracy of the ECG analysis program in analysing morphology.

CSE Code	Cardiac Disorder	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	Prevalence
11	Normal	82.9	94.2	81.2	94.8	1056/4700
21	Left Ventricular Hypertrophy	63.8	86.9	41.5	94.3	596/4700
22	Right Ventricular Hypertrophy	21.4	98.9	22.7	98.8	70/4700
23	Biventricular Hypertrophy	29.4	100.0	94.9	99.0	63/4700
31	Anterior Myocardial Infarction	64.9	88.2	47.9	93.8	673/4700
32	Inferior Myocardial Infarction	72.8	83.4	62.5	89.0	1293/4700
33	Combined Myocardial Infarction	69.0	96.1	69.2	96.1	527/4700
41	Left Bundle Branch Block	93.9	96.8	60.6	99.7	231/4700
42	Right Bundle Branch Block	93.8	96.7	63.8	99.6	272/4700
43	Non Specific Bundle Branch Block	22.3	98.5	37.1	97.0	175/4700
44	Incomplete Left Bundle Branch Block	47.4	98.1	9.4	99.8	19/4700
45	Incomplete Bundle Branch Block	33.3	99.0	11.3	99.7	18/4700
46	Left Anterior Fascicular Block	67.1	97.5	67.6	97.4	346/4700
47	Left Posterior Fascicular Block	50.0	99.2	2.5	100	2/4700
81	Myocardial Ischemia or Lesion	87.7	87.6	80.0	92.7	1696/4700

Total Accuracy: 75.0

C. Cardionics/UCL Rhythm Database

The performance of the ECG analysis program in analysing arrhythmias was evaluated using a database of 200 ECGs. Rhythm statements produced by the program were mapped to a common set of pathologies, and its performance was compared to a cardiologist diagnosis. The mapping of rhythm statements generated by CardioView3000 to rhythm test codes is listed in Table 5.

Table 3. Statistical accuracy of the ECG analysis program in analysing rhythm.

Rhythm Test Code	Rhythm	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	Prevalence
100	Normal sinus rhythm	92.4	89.6	81.3	96.0	66/200
101	Sinus arrhythmia	80.0	95.3	47.1	98.9	10/200
103	Atrial ectopic rhythm	66.7	100	100	99.5	3/200
105	Atrial flutter	15.4	99.5	66.7	94.4	13/200
106	Atrial fibrillation	88.8	93.1	92.6	89.6	98/200
108	Junctional tachycardia	75.0	100	100	99.5	4/200
111	Pacemaker	75.0	100	100	99.5	4/200
113	Sinus tachycardia	71.4	97.4	50.0	98.9	7/200
114	Occasional atrial extrasystoles	68.8	95.1	55.0	97.2	16/200
115	Frequent atrial extrasystoles	83.3	96.9	45.5	99.5	6/200
116	Unifocal ventricular extrasystole(s)	87.5	94.7	84.0	96.0	48/200
117	Multifocal ventricular extrasystole(s)	83.3	97.9	55.6	99.5	6/200
118	Ventricular bigeminy	66.7	97.9	50.0	99.0	6/200
119	Frequent ventricular extrasystoles	33.3	97.4	28.6	97.9	6/200
120	First degree AV block	57.1	96.9	40.0	98.4	7/200

Total Accuracy: 80.3

Mapping Morphology Statements to CSE Codes

Table 4. Translation Table for ECG Morphology Statements to CSE Diagnostic Codes

Statement Code	Morphology Statement	CSE Code	Test Database
106	Short PR interval	41A	B
109	Low QRS voltages	41A	B
110	Complete left bundle branch block	41A	B
111	Atypical complete left bundle branch block	41A	B
112	Incomplete left bundle branch block	44A	B
113	Possibly with left ventricular hypertrophy	21C	A,B
114	Complete right bundle branch block	42A	B
115	Atypical complete right bundle branch block	42A	B
116	Incomplete right bundle branch block	45A	B
117	Non systematic major intraventricular block	43A	B
118	Non systematic minor intraventricular block	48A	B
119	Left anterior fascicular block	46A	B
120	Possible left anterior fascicular block	46B	B
122	Left posterior fascicular block	47A	B
123	Right QRS axis deviation	***	
124	Left QRS axis deviation	***	
125	Possible bifascicular block	50C	B
126	Bifascicular block	50A	B
127	Left posterior fascicular block cannot be ruled out	47C	B
128	Premature QRS in right precordials, positional variance	11B	A
129	Premature QRS in right precordials, posterior infarct cannot be ruled out	11B	A
130	Late QRS transition in left precordials, positional variance	11B	A
131	Compatible with bundle branch block	42C	B
135	Biventricular hypertrophy with wide QRS and secondary abnormal repolarisation, possible left ventricular strain	23A	A,B
136	Biventricular hypertrophy with secondary abnormal repolarisation, possible left ventricular strain	23A	A,B

Statement Code	Morphology Statement	CSE Code	Test Database
137	Biventricular hypertrophy with wide QRS and secondary abnormal repolarisation, possible right ventricular strain	23A	A,B
138	Biventricular hypertrophy with secondary abnormal repolarisation, possible right ventricular strain	23A	A,B
139	Biventricular hypertrophy with wide QRS and secondary abnormal repolarisation	23A	A,B
140	Biventricular hypertrophy with secondary abnormal repolarisation	23A	A,B
141	Biventricular hypertrophy with wide QRS	23A	A,B
142	Biventricular hypertrophy	23A	A,B
143	Possible Biventricular hypertrophy	23A	A,B
144	Biventricular hypertrophy cannot be ruled out	23A	A,B
145	Left ventricular hypertrophy with wide QRS, secondary abnormal repolarisation, possibly left ventricular strain	21A	A,B
146	Left ventricular hypertrophy with secondary abnormal repolarisation, possibly left ventricular strain	21A	A,B
147	Left ventricular hypertrophy with wide QRS and secondary abnormal repolarisation	21A	A,B
148	Left ventricular hypertrophy with secondary abnormal repolarisation	21A	A,B
149	Left ventricular hypertrophy with wide QRS	21A	A,B
150	Left ventricular hypertrophy	21A	A,B
151	High QRS voltage possible left ventricular hypertrophy	21C	A,B
152	High QRS voltage probably normal variant	11B	A,B
155	Right ventricular hypertrophy with wide QRS and secondary abnormal repolarisation, possibly right ventricular strain	22A	A,B
156	Right ventricular hypertrophy with secondary abnormal repolarisation, possibly right ventricular strain	22A	A,B
157	Right ventricular hypertrophy with wide QRS and secondary abnormal repolarisation	22A	A,B
158	Right ventricular hypertrophy with secondary abnormal repolarisation	22A	A,B
159	Right ventricular hypertrophy with wide QRS	22A	A,B
160	Right ventricular hypertrophy	22A	A,B
161	Possible right ventricular hypertrophy	22B	A,B

Statement Code	Morphology Statement	CSE Code	Test Database
162	Right ventricular hypertrophy cannot be ruled out	22C	A,B
169	Atypical Q wave in lead III	11B	A
171	Inferior infarction, probably acute	32A	A,B
172	Inferior infarction, probably recent or with ventricular aneurysm	32A	A,B
173	Inferior infarction, probably old	32A	A,B
175	Possible inferior infarction, probably old	32B	A,B
176	Inferior infarction cannot be ruled out	32C	A,B
177	Possibly associated with lateral extension.	31C	A,B
181	Inferoposterior infarction, probably acute	32A	A,B
182	Inferoposterior infarction, probably recent or with ventricular aneurysm	32A	A,B
183	Inferoposterior infarction, probably old	32A	A,B
184	Possible inferoposterior infarction, probably old	32B	A,B
185	Inferoposterior infarction cannot be ruled out	32C	A,B
186	Possible posterolateral infarction	33B	A,B
187	Possible posterior infarction	32B	A,B
188	Posterior infarction cannot be ruled out	32C	A,B
190	Associated with a peri-infarction block (190)	***	
191	Anteroseptal infarction, probably acute	31A	A,B
192	Anteroseptal infarction, probably recent or with ventricular aneurysm	31A	A,B
193	Anteroseptal infarction, probably old	31A	A,B
195	Possible anteroseptal infarction, probably old	31B	A,B
201	Anterior infarction, probably acute	31A	A,B
202	Anterior infarction, probably recent or with ventricular aneurysm	31A	A,B
203	Anterior infarction, probably old	31A	A,B
205	Possible anterior infarction, probably old	31B	A,B
211	Lateral infarction, probably acute	31A	A,B
212	Lateral infarction, probably recent or with ventricular aneurysm	31A	A,B
213	Lateral infarction, probably old	31A	A,B
214	Possible lateral infarction, probably recent or with ventricular aneurysm	31B	A,B
215	Possible lateral infarction, probably old	31B	A,B
216	Lateral infarction cannot be ruled out	31C	A,B
217	Anterolateral infarction, probably acute	31A	A,B

Statement Code	Morphology Statement	CSE Code	Test Database
218	Anterolateral infarction, probably recent or with ventricular aneurysm	31A	A,B
219	Anterolateral infarction, probably old	31A	A,B
221	Widespread anterior infarction, probably acute	31A	A,B
222	Widespread anterior infarction, probably recent or with ventricular aneurysm	31A	A,B
223	Widespread anterior infarction, probably old	31A	A,B
229	Ischemic ST-T changes compatible with epicardial injury in anterolateral leads	81A	B
231	Ischemic ST-T changes compatible with epicardial injury in inferior leads	81A	B
232	Ischemic ST-T changes compatible with epicardial injury in lateral leads	81A	B
233	Ischemic ST-T changes compatible with epicardial injury in anterior leads	81A	B
236	Ischemic ST-T changes in posterolateral leads	81A	B
237	Ischemic ST-T changes in inferoposterolateral leads	81A	B
238	Ischemic ST-T changes in inferoposterior leads	81A	B
239	Ischemic ST-T changes in posterior leads	81A	B
240	Possible ischemic ST-T changes in posterior leads	81A	B
241	Ischemic ST-T changes in inferior leads	81A	B
242	Ischemic ST-T changes in lateral leads	81A	B
243	Ischemic ST-T changes in anterior leads	81A	B
244	Ischemic ST-T changes in anterolateral leads	81A	B
251	Ischemic ST-T changes compatible with subendocardial injury in inferior leads	81A	B
252	Ischemic ST-T changes compatible with subendocardial injury in lateral leads	81A	B
253	Ischemic ST-T changes compatible with subendocardial injury in anterior leads	81A	B
254	Ischemic ST-T changes compatible with subendocardial injury in anterolateral leads	81A	B
255	Ischemic ST-T changes compatible with subendocardial injury in inferoapical leads	81A	B
261	Ischemic ST-T changes compatible with subendocardial injury in inferoapical leads	81A	B
262	Ischemic ST-T changes compatible with subendocardial injury in lateral leads	81A	B
263	Ischemic ST-T changes compatible with subendocardial injury in anterior leads	81A	B

Statement Code	Morphology Statement	CSE Code	Test Database
264	Ischemic ST-T changes compatible with subendocardial injury in anterolateral leads	81A	B
265	Ischemic ST-T changes compatible with subendocardial injury in inferoapical leads	81A	B
271	Abnormal repolarisation, may be digitalis-effect	81A	B
272	Widespread abnormal repolarisation cannot be ruled out	81A	B
273	Abnormal repolarisation, may be electrolytic unbalance	81A	B
274	Abnormal repolarisation, may be unspecific	81B	B
275	Abnormal repolarisation, possible coronaric insufficiency	81B	B
280	RSR' in V1 could be normal	11A	A,B
282	QRS within the normal limits	11A	A,B
283	Normal morphology	11A	A,B
284	Prolonged Q-T interval	81A	B

Test Database A: CSE Database (1220 ECGs)
Test Database B: Cardionics/UCL Database (4700 ECGs)

Mapping of Rhythm Statements to Rhythm Test Codes

Table 5. Translation Table of ECG Rhythm Statements to Rhythm Test Code

Statement Code	Rhythm Statement	Rhythm Test Code	Test Database
001	Pacemaker rhythm	111	C
002	Regular rhythm	100	C
004	Normal sinus rhythm	100	C
005	Sinus bradycardia	100	C
006	Marked sinus bradycardia	112	C
007	Sinus tachycardia	113	C
009	Sinus bradycardia with 1st degree AV block	112	C
010	Sinus tachycardia with 1st degree AV block	113	C
011	Slow atrial rhythm	103	C
012	Coronary sinus rhythm	102	C
013	Junctional rhythm, atrial fibrillation with AV block cannot be ruled out	107	C
014	Accelerated junctional rhythm	107	C
015	Junctional tachycardia	108	C
016	Supraventricular tachycardia	108	C
017	RIVA episode	110	C
018	Ventricular or supraventricular tachycardia with aberrant conduction	110	C
019	Sinus rhythm	100	C
020	Atrial flutter with 1:1 conduction	105	C
021	Atrial flutter with 2:1 conduction	105	C
022	Atrial flutter with 3:1 conduction	105	C
023	Atrial flutter with 4:1 conduction	105	C
024	Atrial flutter with 5:1 conduction	105	C
025	Atrial flutter with variable AV block	105	C
026	Atrial fibrillation	106	C
029	Irregular rhythm with atrial extrasystole(s)	114	C
030	Sinus arrhythmia	101	C
031	Atrial bigeminy	115	C
032	Atrial trigeminy	115	C
033	Intermittent atrial bigeminy	115	C
035	Atrial fibrillation cannot be ruled out	106	C
037	Atrial ectopic beats	103	C
044	Ventricular bigeminy	118	C
045	Ventricular trigeminy	119	C
046	Intermittent ventricular bigeminy	118	C
052	Unifocal ventricular extrasystole(s)	116	C
053	Multifocal ventricular extrasystole(s)	117	C

Statement Code	Rhythm Statement	Rhythm Test Code	Test Database
054	Ventricular extrasystoles with aberrant conduction	114	C
055	Atrial extrasystole(s)	114	C
056	Ventricular extrasystole(s)	116	C
057	Interpolated ventricular extrasystole(s)	116	C
058	Ventricular extrasystole(s) with full compensation	116	C
059	Ventricular extrasystole(s) without full compensation	116	C
060	Supraventricular extrasystole(s)	114	C
061	Supraventricular extrasystole(s), Ashman phenomenon	114	C
062	Fused ventricular extrasystoles	116	C
065	A sinus rhythm	100	C
066	A junctional rhythm	107	C
068	Ventricular couplets	119	C
069	Ventricular triplets	119	C
070	Run of ventricular extrasystoles	119	C
071	Atrial couplets	115	C
072	Atrial triplets	115	C
073	Run of atrial extrasystoles	115	C
079	Atrial pacing	111	C
080	Sinus arrhythmia with 1st degree AV block	101	C
081	Junctional bradycardia	107	C
084	Ventricular quadrigeminy	116	C
086	Extreme bradycardia	112	C
087	Idioventricular rhythm	110	C

Test Database C: Cardionics/UCL Rhythm Database (200 ECGs)