ECG - Basics

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Einthoven

Photograph of a Complete Electocardiograph, Showing the Manner in which the Electrodes are Attached to the Patient, in this Case the Hands and One Foot Being Immersed in Jars of Salt Solution
Conduction System
Ventricular depolarisation sequence

Cardiac vectors
Mean vector

Numbers indicate sequence of ventricular depolarization

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Basics

- Electrical current moving toward the positive electrode causes positive deflection.
- Electrical current moving away from the positive electrode causes negative deflection.
- The stronger the current, the stronger the deflection.
Limb leads - Lead orientation

- Lead I: RA (-) to LA (+)
- Lead II: RA (-) to LF (+)
- Lead III: LA (-) to LF (+)

- Aug. Unipolar
  - Lead aVR: RA (+) to [LA & LF] (-) (Rightward)
  - Lead aVL: LA (+) to [RA & LF] (-) (Leftward)
  - Lead aVF: LF (+) to [RA & LA] (-) (Inferior)
Chest Leads – Positioning

**Lead V₁**: The electrode is at the fourth intercostal space just to the right of the sternum.

**Lead V₂**: The electrode is at the fourth intercostal space just to the left of the sternum.

**Lead V₃**: The electrode is at the line midway between leads V₂ and V₄.

**Lead V₄**: The electrode is at the midclavicular line in the fifth interspace.

**Lead V₅**: The electrode is at the anterior axillary line at the same level as lead V₄.

**Lead V₆**: The electrode is at the midaxillary line at the same level as lead V₄.
Normal
Waves and intervals

- P Wave
- PR Interval
- QRS Complex
- ST Segment
- T Wave
- U Wave
- RR Interval
- QT Interval

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Waves and significance

- **P wave**: the *sequential* depolarisation of the right and left atria.
- **QRS complex**: right and left ventricular depolarisation.
- **ST-T wave**: ventricular repolarisation.
- **U wave**: origin for this wave is not clear - but probably represents "after-depolarisations" in the ventricles, ?papillary muscle depolarisation.
- **PR interval**: time interval from onset of atrial depolarisation (P wave) to onset of ventricular depolarisation (QRS complex).
- **QRS duration**: duration of ventricular muscle depolarisation.
- **QT interval**: duration of ventricular depolarization and repolarisation.
- **RR interval**: duration of ventricular cycle (an indicator of ventricular rate).
- **P interval**: duration of atrial cycle (an indicator or atrial rate).
QT and Axis

- **QT interval** – Beginning of QRS to end of T wave. Corrected for heart rate –
- **QRS axis** - Normal range - -30° to +100°.
- **Axis Deviation** –
  - Left axis deviation (i.e., superior and leftward) is defined as -30° to -90°, and
  - Right axis deviation (i.e., inferior and rightward) is defined as +100° to +150°.
  - Extreme axis deviation (NW axis) is the remaining bit.
  - By convention axes above the horizontal are negative and those below are positive. (See diagram below)
Hex-axial system and leads
Hex-axial system
Another way

Diagram showing electrocardiographic leads and their respective angles.

Legend:
- aVR
- aVL
- aVF
- I
- II
- III

Angles:
- 0°
- 30°
- 60°
- 90°
- 120°
- 150°
- 180°
- -30°
- -60°
- -90°
- -120°
- -150°
- -180°
QRS Axis

- First find the *iso-electric* lead if there is one; i.e., the lead with equal forces in the positive and negative direction. Usually this is the lead with the smallest QRS deflection.

- The QRS axis is *perpendicular* to that lead's orientation (see diagram above). With an error margin of +/- 30. To fine tune, look where the main deflection in the iso-electric lead is and adjust 15° in that direction.

- Since there are two perpendiculars to each iso-electric lead, chose the perpendicular that best fits the direction of the other ECG leads.

- If there is no iso-electric lead, there are usually two leads that are nearly iso-electric, and these are always 30° apart. Find the perpendiculars for each lead and chose an approximate QRS axis within the 30° range.

- Occasionally each of the 6 frontal plane leads is small and/or iso-electric. The axis cannot be determined and is called *indeterminate*. This is a normal variant.
Cheat code

- Another cheat
- Use I and aVF
- Both positive = normal
- I+, aVF - = LAD
- I-, aVF + = RAD
- Both negative = extreme axis deviation.

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Reading an ECG

- Measurements – rate, PR, QRS, QT interval
- Rhythm
- Conduction
- Waveform analysis
- *Remember - look for standardisation and paper speed.*
Rhythm analysis

- Vent. rate – 1500/R-R interval in small squares or 300/R-R interval in big squares
- Atrial rate
- Site of origin – SA, A, AV, V
- Regularity of rhythm – reg, reg. Irreg, irreg-irreg
- Cherchez le P
- P and QRS relation
- Ectopics and compensatory intervals
- Impulse conduction – antero, retro, orthodromic etc
Waveform analysis

- P waves - seen best in L2 and V1
- P pulmonale, p mitrale
- Criteria for atrial enlargement
- QRS - duration - 80-100mS. >120 mS - bundle branch block.
- T wave – direction, shape, relation to preceding QRS complex.
Conduction abnormalities

- Wolff-Parkinson-White Syndrome
- Lown-Ganong-Levine Syn.
- Long QT
Brady-arrythmias

- Sinus bradycardia < 60bpm
- Sinus pause, sinus arrest
- Sino-atrial block
- First degree heart block
- Type 1 and Type 2 second degree block
- Complete heart block
- Sick sinus syndrome
1st degree AV block (PR = 280 ms)
Lead $V_1$   "Classic Wenckebach"
Lead $V_1$
Complete heart block
Escape Rhythms

- Junctional Escape Rhythm
- Idio-ventricular Rhythm
- Accelerated idio-ventricular Rhythm (AIVR)
Tachy-arrhythmias - Analysis

- Broad or narrow complex.
- Regular or irregular.
- P wave and P-QRS relationship.
- Atrial tachycardia, atrial flutter, AF and AVRT and AVNRT.
- Ventricular tachycardia vs SVT with aberrancy and AF in WPW.
- VF and polymorphic VT/Torsades.
Atrial flutter
Beware of this! R Menon
Bundle branch blocks

- Complete BBB – QRS duration > 120 ms
- RBBB – RSR’, or rsR’, rSR’ or W pattern in V1 and prolongation of terminal QRS deflection in left sided leads –avL, V6 etc, axis normal –(remember hemi-blocks)
- LBBB – Lt. Leads show monophasic upward M pattern QRS, discordant ST seg.
- BBB – if *terminal* deflection of the QRS complex is positive, the T wave should be negative and vice versa
- Bifascicular, trifascicular and hemiblocks
Myocardial Ischaemia - Chronic

- 90% of cases resting ECG is normal.
- ST segment changes – especially ST segment depression – though usually in acute ischaemia rather than chronic
- T wave changes – usually T wave inversion though can be biphasic T wave.
- May show evidence of previous MI such as Q waves and reduced r wave height.
Myocardial ischaemia - acute NSTEMI and unstable angina

- ST segment depression usually; rarely ST elevation as in Prinzmetal’s angina.
- T wave – flat, inverted or biphasic- not very specific.
- U wave inversion – rare but said to be specific.
- Development of Q waves in the absence of ST elevation can occur. Loss of R wave height can also be seen.
First change is usually peaking of T wave – so called tall peaked T waves or hyperacute T waves.

ST segment elevation in at least 2 consecutive leads. To thrombolyse/PCI follow the criteria.

Convex upward ST segment elevation.

Later ST elevation comes down and T wave starts to invert.

Then there is loss of R wave height and development of Q waves (significant Q – more than 30 ms in width and 25% of R wave height).

Even later the T waves may become upright but Q waves usually persist.

Persistent ST elevation in the absence of pain for weeks after MI may indicate the development of aneurysm.
Unusual patterns in ischaemia

- Posterior MI – Usually associated with inferior MI. Presents with ST depression in V1, V2 along with upright T wave. Look for posterior leads – V7,8 and 9. Reverse ECG paper and look.
- New onset LBBB or RBBB.
- Right ventricular MI – Again along with inferior MI. If suspected – ask for right ventricular leads- RV1- RV6. Sometimes you can see ST elevation in V1 and V2.
- Clinically raised JVP with RVS3 and clear chest.
Acute Anterior MI
Antero-lateral STEMI
Acute Inferior MI
Acute Inferior STEMI
Posterior MI
LVH and RVH

- **RVH** – R V1 + SV5/V6 > 11, R/S V1 > 1
- **LVH** – voltage criteria SV1+ RV5/V6 > 35, RaVL > 11, Cornell etc.
- Other criteria – LAE, ‘strain pattern’, intrinsicoid deflection, LAD etc
- Romhild-Estes criteria
- Atrial enlargement – LAE –P mitrale, P pulmonale, biatrial
LVH with strain

09-JUL-1917 (79 yr)
Male Black

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RVH with strain
RVH with strain
Electrolyte abnormalities

• Hyperkalemia – T wave tall/peaked, flat P, PR lengthening, qrs widening, ‘sine wave’ and asystole

• Hypokalemia – Flat/inv T, prominent U wave, QT prolongation, atrial paralysis and TdP.

• Hypocalcaemia – QT prolongation, esp ST segment prolongation

• Hypomagnesaemia – similar to hypocalcaemia
Hyperkalemia
Hypokalemia
Pericarditis – ST segment elevations in multiple leads are seen not conforming to any vessels. Usually concave upwards ST segment elevation. In all leads except aVR and occ. V1. T wave changes may be seen.

Myocarditis – T wave changes and arrhythmias are the usual pattern in acute setting. Later may have changes of dilated cardiomyopathy
Normal Variants

Early repolarisation: ST elevation in usually lateral leads in young. May go away with exercise or occ. hyperventilation. Usually there is a J point deflection.

Persistent juvenile pattern: Persistence of the juvenile pattern of T wave inversion in anterior leads into adulthood, usually in women.
Early Repolarisation
Rarities

Long QT syndromes such as Jervell and Lange-Neilsen and Romano-Ward - superseded by genetic classification now.

Brugada: ST elevation in V1/V2, partial RBBB pattern. J point deflection and coved upwards ST elevation are usual. F Hx or h/o tachyarrhythmia necessary for diagnosis. Ajmaline test.

Thank You