Electrocardiography

Analysis and Interpretation
software vs physician

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ECG, EKG

It is the procedure of recording the electrical activity of the heart. The electrode combination records the difference of potential difference at two sites on the body. The potential differences are produced due to the electrical activity of the heart.

**Electrocardiograph is the machine**
**Electrocardiogram is the record**

The characteristic shape and timing of the ECG waves are due to the spread of wave of depolarization and repolarization associated with each heart beat.
Spread of impulse in the heart

Differences in the speed of spread is critical for proper function
Standard Limb Leads

Einthoven’s triangle
Einthoven’s Law
Augmented Limb Leads

Similarly, aVL and aVF
Chest (Precordial) Leads

Wilson’s Central terminus
Vectorial direction of standard leads

- aVR
- aVF
- aVL
- I
- II
- III
Vectorial direction of chest leads
Interpretation of ECG

Individual waveform of beats is used for the detection of

- ischemia / infarction
- conduction deficits
- arrhythmia
- hypertrophy
- electrolyte imbalance

Major method used by the clinicians is the Pattern Recognition method.

* Vector analysis is not generally used explicitly.
Interpretation of ECG

ECG paper = 5mm x 5 mm
Speed of paper = 25 mm/sec
calibration = 10 mm/mv

Always calibrate
Record atleast 3 beats per lead
Write patients details

Record leads in following sequence

Limb leads (I, II, III), Augmented Leads (aVF, aVR, aVL) and Chest leads (V1 to V6)
What to read / How to read an ECG?

Is there a sinus rhythm: i.e. p wave followed by QRS complex?
   Is p wave normal in duration and shape? Check in all leads
calculate rate = 300/number of large squares or 1500/no. of large squares

Is the QRS complex normal in duration and amplitude?
   see the QRS complex amplitude in all the leads to detect hypertrophy or
   axis deviation

Calculate PR interval
Calculate QT interval
Check ST segment, Is there a current of injury?
Check T waves
Who does the interpretation?

Trained cardiologist is the **gold standard** for interpretation.

In practice, the preliminary interpretation will be done by the residents, physicians many of whom may not be cardiologists.

Numerous studies have shown that % satisfactory interpretation ranges from 40 – 60 % in hospital settings.

- Incorrect diagnosis
- Incomplete annotation and reporting.

Computer based method of ECG interpretation

Computer assistance to the physician
How good is the software?

Does a computer-based ECG-recorder interpret electrocardiograms more efficiently than physicians?


Setting

ECG (474) from emergency, OPD, General practice

Results (in terms of interpretation)

physicians : 64 %
computer based method : 82%
How good is the software?

Common errors in computer electrocardiogram interpretation

Guglin M and Thatai D. Int J Cardiol 2006; 106: 232 - 237

Number of ECG tested: 1296
Software vs two cardiologist
  disagreement: 15.9 % cases
  major disagreement in diagnosis (84%) of
    conduction deficits
    arrhythmia
  misdetection of
    chamber enlargement (3.4%)
    myocardial ischemia (7.8%)
How good is the software?

Use of computer assistance in interpretation of ECG

Setting

Non-cardiology resident were asked to interpret ECG with or without computer assistance

Without assistance = 48.9 %
With assistance = 55.4%

Type of Computer assistance
  Correct only
    68.1 %
  Incorrect only
    48.3%

Erroneous computer interpretation influences the physician more than the correct interpretation
How good is the software?


SHOs have a high error rate when interpreting ECGs, which is not significantly reduced by access to a computer generated report. Junior doctors should continue to seek expert senior help when they have to interpret a difficult ECG.
Other utilities of ECG where computers are very useful

Heart rate variability

Poincare plot (extremely useful in detection of ectopies)

Baro-reflex sensitivity

ECG gated pulse wave velocity

? Vectorial (3-D) spread of the cardiac impulse
Quantification of heart rate variability

Electrocardiogram

Conditions and recording specifications (digital)

- **Filter**: Bandpass: 0.5 Hz – 35 Hz
- **Sampling Frequency**: >128 Hz, 500 Hz
- **Duration**: 5 min for short term variability
Detection of peak of R wave

Algorithm

Voltage of R wave (Threshold method)
Slope of R wave (Differentiation)

Pre-processing of ECG signal

threshold

P wave  Q wave  S wave  T wave
RR intervals (msec): 760, 820, 756, 690, 758, 834.....

Interpolation: need and method
Re-sampling at 4 – 7 Hz

Nyquist theorem
Quantification

Time domain (statistics)

Frequency domain

Non-Linear

RR time series
ECG gating based measurement of pulse-wave velocity

- ECG – carotid
- ECG – radial
- ECG – brachial
- ECG – ankle
Challenges and future direction

- Better algorithms for time-voltage calculations
- Validation of the computer software in properly conducted trials
- Incorporation of vectorial methods / non-linear methods standard devices in OPD, ICU
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