BASIC CONCEPT OF ECG

Electrocardiogram

The electrocardiogram (ECG) is a recording of cardiac electrical activity. The electrical activity is readily detected by electrodes attached to the skin. After the electric current is detected it is amplified, either displayed on a monitor or recorded on ECG graph paper as waves and complexes.

ECG Leads

To measure the heart’s electrical activity a routine ECG normally employs 12 leads. The 12 conventional leads may be divided electrophysiologically into two groups, one being orientated in the frontal plane of the body, and the other in the horizontal plane.

Bipolar standard leads I, II and III, and unipolar augmented extremity leads AVR, AVL and AVF are orientated in the frontal plane of the body.

The precordial leads V1, V2, V3, V4, V5 and V6 are orientated in the horizontal plane of the body.

Standard bipolar leads:
I    - Rt arm negative to Lt arm positive
II   - Rt arm negative to Lt leg positive
III  - Lt arm negative to Lt leg positive

Augmented (Unipolar) leads:
AVR - Rt arm
AVL - Lt arm
AVF - Lt leg
Precordial or chest (Unipolar) leads
V1 - 4th intercostal space at Rt sternal boarder
V2 - 4th intercostal space at Lt sternal boarder
V3 - midway between V2 and V4
V4 - 5th intercostal space in midclavicular line
V5 - 5th intercostal space in anterior axillary line
V6 - 5th intercostal space in midaxillary line

Waveforms and Current Flow
The direction in which the electric current flows determine how the waveforms appear on the ECG tracing. An electric current flowing toward the positive pole will produce a positive deflection; an electric current flowing away from the positive pole will produce a negative deflection. If the direction of the wave is at right angles at the recording electrode, it produces no deflection at all. The size of the wave deflection will depend on the magnitude of the electrical current flowing toward the individual pole.
**Cardiac Vectors vs ECG**

The wave of depolarization that spreads through the heart during each cardiac cycle has vector properties defined by its direction and magnitude. At any instant depolarization occurs in multiple directions as the activation wave is propagated. Thus the instantaneous direction of the wave recorded at the skin surface is the resultant of multiple ‘minivectors’ through the heart.

Cardiac vectors of each cardiac cycle include:

1. Atrial depolarization vector
2. Septal depolarization vector
3. Apical and early ventricular depolarization vector
4. Late ventricular depolarization vector
5. Ventricular repolarization vector
<table>
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<th>Resting state</th>
<th>Atrial depolarization</th>
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<td>Septal depolarization</td>
<td>Apical and early ventricular depolarization</td>
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<td>Late ventricular depolarization</td>
<td>Ventricular repolarization</td>
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ECG Paper

The paper on which the ECG is recorded is divided into 5 mm squares, each subdivided into smaller 1 mm squares. Time is measured horizontally, and voltage or force of contraction vertically. At the usual recording speed of 25 mm/sec, one small square in the horizontal direction represents 0.04 second, and the edge of one large square represents 0.20 second. The ECG is usually standardized so that one square in the vertical direction represents 0.1 mV; thus, the edge of one large square represents 0.5 mV and the edge of two large square represents 1 mV.

Components of the Electrocardiogram
**P wave**
- It represents atrial depolarization
- It is produced by the firing of the SA node and the resultant spread of depolarization through the right atrium and then the left atrium
- 0.06 to 0.11 in width
- 2 to 2.5 mm in height

**PR intervals**
- It measures the AV conduction time transmitting impulse from SA node, via AV node to the bundle of His immediately before the onset of ventricular depolarization
- It is measured from the beginning of the P wave to the beginning of the QRS complex
- Normal range is from 0.12 to 0.20 second

**QRS complex**
- It represents ventricular depolarization
- Q wave is the first negative deflection in the QRS complex, normally less than 0.04 second
- R wave is the first positive deflection
- S wave is the negative deflection after the R wave
- It is measured from the beginning of the QRS complex to the end of the QRS complex
- The normal range is 0.06 to 0.10 second

**J point**
- It marks the end of the QRS complex and the beginning of the ST segment
- The zero reference potential

**ST segment**
- It represents the end of ventricular depolarization and the beginning of ventricular repolarization
- It extends from the end of the S wave to the beginning of the T wave
- Usually isoelectric, may be 1 mm above or 1/2 mm below the isoelectric line

**T wave**
- It represents ventricular repolarization
it follows the QRS complex and the ST segment
5 mm or less in standard leads; 10 mm or less in precordial leads

**QT interval**
- it represents the time required for ventricular depolarization and repolarization to take place
- it measures from the beginning of the QRS complex to the end of the T wave
- 0.36 to 0.44 second

**U wave**
- it represents repolarization of the His-Purkinje fibers
- may occasionally be seen following the T wave

### Analysis of the ECG - 5 step Method

![ECG tracings]

**STEP 1: Evaluate the rhythm (atrial and ventricular)**
1. Compare the P-P and R-R intervals in several cycles.
2. If the P-P (R-R) intervals are consistently the same, the atrial (ventricular) rhythm is regular.
3. If the P-P (R-R) intervals are not consistently the same, the atrial (ventricular) rhythm is irregular.
4. If there is a pattern to the irregularity, the atrial (ventricular) rhythm is considered to be regularly irregular.

**STEP 2: Calculate the rate (atrial and ventricular)**
There are several ways to calculate heart rate. Some are given to use with regular rhythms and one to use with irregular rhythms.

**Regular rhythms**
1. Count the number of small squares between two R waves.
2. Divide the number of small squares into 1500
or
1. Count the number of large squares (one large square = 0.20 second) between two
R waves.
2. Divide that number of large squares into 300

*Irregular rhythms*
1. Count the number of R waves in a 6 second strip and multiply by 10
2. Count the number of R waves in a 3 second strip and multiply by 20

**STEP 3: Evaluate the P wave**
1. Are P waves present?
2. Do the P waves have a normal shape? (small and rounded)
3. Are all the P waves similar in size and shape?
4. Do you see a one-to-one relationship between the P waves and the QRS complexes?

**STEP 4: Calculate the duration of the PR interval**
1. Does the duration of PR interval fall within normal limits?
2. Is the PR interval constant?

**STEP 5: Calculate the duration of the QRS complex**
1. Does the duration of the QRS complex fall within normal limits?
2. Are all the QRS complexes the same size and shape?
3. Are any QRS complexes present that appear different from the other QRS complexes on the strip?
4. Is there a QRS complex for each P wave?

**Continuous Cardiac Monitoring**
Continuous monitoring of cardiac rhythm in the critically ill patient is an important aspect of cardiovascular assessment. The nurses place a patient on an electrocardiographic monitor to:
1. Provide a continuous picture of the patient’s cardiac electrical activity.
2. Record cardiac electrical activity for diagnostic or documentation purposes.
3. Anticipate and treat various dysrhythmias.

**Points to be remember when monitoring patient’s ECG**
1. A prominent P wave should be displayed if organized atrial activity is present. Leads that show the P wave clearly should be chosen.
2. The QRS amplitude should be sufficient to properly trigger the ratemeter.
3. The patient’s precordium must be kept exposed so that defibrillation paddles can be readily used if necessary.

4. Monitoring is for rhythm interpretation only. One should not try to read ST abnormalities or attempt more elaborate ECG interpretation.

5. Artifacts should be noted: a straight line will show if the electrode is loose, or a bizarre, wavy baseline resembling ventricular fibrillation may appear if an electrode is loose or the patient moves.

6. Always remember that any ECG findings should be correlated with clinical observation of the patient.

References

MAK WAI LING
Nurse Specialist
YCH ICU
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