Keeping abreast of developments in an ever-changing health service

CONTINUING PROFESSIONAL DEVELOPMENT is essential for nurses and midwives practising in an ever-changing healthcare environment. With this in mind W/N has taken the decision to expand its Continuing Education section for 2006 and will focus on two clinical areas which impact on all areas of the Irish health service – namely cardiology and diabetes. Cardiovascular disease and type 2 diabetes can be considered the most significant public health problems that we have faced in recent times, so much so that we are facing the prospect of a reduction in life expectancy if the dual problem is not tackled.

The Cardiology Module to date has focused on: Cardiac risk protection in people with type 2 diabetes; Women and stroke; Role of cardiac rehabilitation; Blood pressure management; Sudden cardiac death; and Lipid management.

This month, in the first of a two-part article on the electrocardiograph, we focus on recording and understanding the meaning behind the ECG. Next month’s article will address the interpretation of the ECG waveforms.

MODULE 12: Cardiology

PART 7

ECG recording: basic principles

by Mary Mooney & Lisa Browne

THE PROCESS of interpreting the electrocardiograph (ECG) is specialised and requires skill, education and experience. Those who are not familiar with the skill and have not had the necessary education should not be expected to make any clinical decisions based on an ECG.

It is important however that a nurse is able to recognise what constitutes a normal ECG and, from this knowledge, identify when an ECG presents abnormally. This process can be enhanced through understanding the fundamental processes and principles which underpin the formation of the ECG. This article will provide the reader with some basic information on the generation of cardiac electrical currents, how these currents produce wave forms and how the ECG machine records these wave forms to produce the ECG. The article is also intended to inform you about the ECG leads and what they represent. The second of this two-part article will address the interpretation of ECG waveforms.

Understanding the physiology

The basic principle of the ECG is that stimulation of a muscle alters the electrical potential of the muscle fibres. Cardiac cells, unlike other cells, have a property known as automaticity, which is the capacity to spontaneously initiate impulses. These are then transmitted from cell to cell by gap junctions that connect cardiac cells to each other.

The electrical impulses spread through the muscle cells because of changes in ions between intracellular and extracellular fluid. This is referred to as action potential. The primary ions involved are potassium, sodium and calcium. The action potential is the potential for action created by the balance between electrical charges (positive and negative) of ions on either side of the cell membrane.

When the cells are in a resting state, the insides are negatively charged compared to the outsides. Membrane pumps act to maintain this electrical polarity (negative charge) of the cardiac cells. Contraction of the heart muscle is triggered by depolarisation, which causes the internal negative charge to be lost transiently. However, following depolarisation, the cardiac cells return again to their resting charge, known as repolarisation.

These waves of depolarisation and repolarisation represent an electrical current and can be detected by placing electrodes on the surface of the body. After the current has spread from the heart through the body, the changes are picked up by the ECG machine and the activity is recorded on previously sensitised paper. The ECG is therefore a graphic representation of the electrical activity in the heart. The current is transmitted across the ECG machine at the selected points of contact of the electrode with the body.

Performing the ECG

The ECG comprises 12 leads: three standard leads (lead I, lead II and lead III); three augmented leads (AVR, AVL and AVF); and six chest leads (V1, V2, V3, V4, V5, V6).

A total of 10 electrodes (points of contact with the body) are used to perform an ECG. It is called a 12 lead ECG because the heart is viewed and grafts are recorded from 12 different viewpoints. Two electrodes are placed on the arms and two on the legs when recording the ECG. These provide the basis for the six limb leads (three standard and three augmented leads). The four limb electrodes record six different views of electrical activity in the heart, while each of the chest electrodes records one lead each.

The standard leads

The limb electrodes are colour coded as follows:

- Red – right arm
- Yellow – left arm
- Green – left leg
- Black – right leg.

The acronym ‘Red Your Green Book’ (applied in a clockwise direction) may assist the reader to recall the correct placement of the leads for recording the 12 lead ECG.

It is important that care is taken to ensure that the leads are correctly placed, as errors in lead placement leads to confusion when interpreting the ECG.
The R wave is the first positive deflection of the QRS complex. A Q wave is not always apparent on the ECG. The P wave represents atrial depolarisation, the QRS complex represents ventricular depolarisation, and the T wave represents repolarisation of the ventricular muscle.

The limb leads are further divided into standard and augmented leads. The standard or bipolar leads have a positive and a negative pole each.

- Lead I looks at the flow of electricity from the right arm to the left arm. It therefore explores the frontal plane of the heart and picks up activity in the left lateral wall of the ventricle.
- Lead II looks at the flow of electricity from the right arm to the left leg. This lead is closest to the heart’s normal vector (main direction of flow from SA node through the conduction system) and is primarily used as the main lead for standard monitoring. This frontal lead looks at activity in the inferior part of the heart.
- Lead III looks at the flow of electricity from the left arm to the left leg. This lead also explores the inferior aspect of the heart.

The facing or exploring lead is always the positive lead. Therefore, in lead I the left arm is the positive pole, in lead II it is the left leg and in lead III it is the left leg also.

The augmented leads

The augmented or bipolar leads have only one pole. The terminal for AVR is the right arm. This lead explores cardiac activity from the right surface of the heart. Under normal circumstances this lead will be negative. That is to say that the P, Q, R, S and T waves will all be negative, as the AVR looks down onto the cavity of the heart.

AVL looks at the left lateral aspect of the heart, as viewed from the left arm. The final augmented lead is AVF, which looks from the left leg to the inferior surface of the heart.

The chest leads

The chest leads represent a positive pole and are placed in six pre-determined positions along the chest wall as shown in the Table. Any electrical force travelling towards one of these leads will create a positive force (seen as a positive deflection on the ECG) and vice versa.

The waves formed and produced on the ECG paper are as a result of depolarisation and repolarisation within the myocardium. The ECG paper is divided vertically and horizontally, measuring voltage and time respectively. One small square on the paper represents 0.04 seconds and the distance across one large square is 0.20 seconds. In terms of voltage, the distance across one small square represents 0.1mV and one large square, 0.5mV.

Formation of the ECG

Cardiac depolarisation begins from the SA node in the right atrium, causing it to contract. The impulse is transmitted from the right atrium to the left atrium, which then contracts. The first positive deflection seen on the ECG represents atrial depolarisation and is labelled the P wave. The normal P wave is < 0.08 seconds (two small squares on the ECG paper) in duration.

There is a short delay between atrial contraction and impulse conduction through the AV node. This period of delay is referred to as the PR interval. It is measured from the beginning of the P wave until the beginning of the R wave. During this time the ECG normally returns to the baseline, which is referred to as the isoelectric line. The PR interval is normally between 0.12-0.20 seconds.

The Q wave, caused by septal depolarisation, is the first negative deflection seen on the ECG after the P wave. A normal Q wave is less than one small square wide. A Q wave is not always apparent on the ECG. An enlarged Q wave is significant and indicative of abnormalities.

There is rapid impulse conduction through the bundle of His, the bundle branches, the fascicles and the purkinje fibres. The deflection seen on the ECG is strongly positive. Conduction spreads through the ventricles from the endocardium to the epicardium. The R wave is the first positive deflection of the QRS complex and the S wave is the first negative deflection after the R wave, seen below the isoelectric line. The normal QRS complex is < 0.12 seconds in duration. This is an indication of the speed of conduction of the ventricular impulses. The ECG graph should return again to the isoelectric line after the S wave.

The final waveform seen on the ECG is the T wave. The T wave represents repolarisation of the ventricular muscle. This simply corresponds with relaxation of the muscle prior to the next electrical impulse. The T wave should be positive and should be of no greater duration than 0.16 seconds. The duration between the S and T waves (ST segment) is not significant. It is important that the ECG graph returns to the isoelectric line between the S wave and the T wave. An abnormal isoelectric line between the S and T waves provides clues to problems with depolarisation and should be noted and reported.

A clue to diagnosis

The recognition of the normal ECG is important for the novice interpreter so that deviations from normal can be detected, reported and treated promptly.

The augmented and standard leads measure the cardiac forces in the frontal plane, while six precordial leads (V1-V6) measure the cardiac forces in the horizontal plane.

It is important to emphasise that the ECG is but a clue to a diagnosis. The interpretation will only be as accurate as the person who interprets it. Therefore it is imperative that those responsible for interpreting ECGs stay abreast with changes in clinical practice. More importantly it is imperative that all healthcare professionals be sufficiently prudent to acknowledge their own limitations and seek assistance whenever in doubt.

The next article in this series will focus on interpreting the ECG.

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References
3. Thaler MS. The Only EKG Book You’ll Ever Need. 4th edn. Lippincott, Williams & Wilkins, Philadelphia 2003