Electrocardiography (2. LF UK)

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ECG Practical: Electrocardiography

1. Introduction

The human heart is a 4 chamber muscular structure in the thoracic cavity, pumping oxygenated blood to all body parts, in a regular yet non-stopping rhythm.

Although being controlled by parts of the Central Nervous System, for rate regulation, the heart generates it’s contractions by itself, this happens by electrical signals (action potentials) taking place in special sites of the heart tissue, called the **Sinoatrial Node** and **Electrical conduction system of the heart,** the electrical impulse is transported to all cardiac tissue, causing the heart to contract, and blood to be ejected.

These electrical signals can be detected in some other areas in the body, such as the skin, by using special electrodes, and provide information on the electrical activity of the heart, and the different phases of a cardiac cycle, the procedure of detection of the cardiac electrical pulses through the skin by electrodes placed on the chest and limbs is called **Electrocardiography** (ECG or EKG), the medical device itself is called an **electrocardiometer** and the Voltage-Time graph produced is called an **electrocardiograph**.

2. Importance in clinical medicine

The electrocardiograph is used mainly for detecting problems related to the heart, via measurements of its electrical activity. The electrical pulse started by the SA node (the natural pacemaker of the heart) is produced by the heart causing contraction of the heart in a specific area and can be detected and shown as ascending and descending lines, or 'waves' (they are not really waves of course as it's just a graph of Voltage against Time. Since the heart is widely interactive with the lungs, problems in breathing may have something to do with the heart and vice versa.

Electrocardiography can be used generally to detect most problems involving the heart. If a patient is experiencing chest pains, dizziness, shortness of breath, bradycardia (slow heartbeat) or tachycardia (fast heartbeat), the ECG may be used to diagnose the heart's electrical activity to find the cause. The ECG may be also used to detect cardiac side effects of diseases or conditions such as high blood pressure, high cholesterol, cigarette smoking, diabetes, and a family history of early heart disease or also of specific medication. If an artificial pacemaker is installed in the heart, the ECG can be used to monitor the functioning of the device in case it is not working properly.

3. Literature review

What are its advantages and disadvantages?

Electrocardiography has remarkable advantages and some disadvantages (both for resting and stress tests)**.**

First of all, it can function as an important indicator of potential causes and consequences of a cardiac disease.

This can be very significant, because it can discover and prevent, for example heart arrhythmia, Hypertrophy (thickness of heart muscle) or heart infarction. Additionally, it is a valid diagnostic tool for the detection of an electrophysiological dysfunction.

With respective to the procedure, it is crucial to emphasise that it is a relatively easy procedure to apply and to perform. Moreover, it is a non-invasive and a painless method, and results most of the time in a fast and accurate diagnosis.

However, it is important to mention that obtaining and analysing the results can be time-consuming, if one does not have automatic ECG analysis software.

In addition, the ECG technologist has to be present to control the device and look after the patient.

In some cases the results do not discover a disorder and the procedure may show results, which do not match the clinical reality. (false negative or false positive results). Clinical experience is needed to interpret the results.

(One point, regarding the stress test can be a possible heart attack or dysrhythmia due to the stressful exercise.)

How does it work?

Electrodes will be attached to the skin of the patient on the limbs and chest area. A conductive gel is also used with the electrodes to aid in the measurement of the electrical activity of the heart. The electrodes record the potentials produced by the polarity changes of the myocardium in millivolt (mV). There are different ECG machines: 3-lead, 5-lead and 12-lead ECG. The 12-lead ECG gives a more complete diagnosis and has in total 10 electrodes, that together provide 12 different angles for viewing the heart. Each different angle is called a lead. These 12 leads are: 3 bipolar limb Einthoven's leads, 3 unipolar limb augmented leads and 6 unipolar precordial leads. For the test, 6 electrodes are located in the chest area around the heart and 4 are symmetrically attached to each of the limbs. The data collected by the electrodes are printed on a graph and analysed by the physician. The test usually takes 5 to 10 minutes.

Are there any risks involved in it's use (for patients and the clinical staff)?

First of all the ECG is a procedure without any risk factors. It represents a simple and painless way to measure the electrical activity of the heart. However, one type of ECG can cause some hazards. During a cardiac **stress test** the patient has to perform physically exhausting exercises. A treadmill or a cardio glider is used. The level of stress depends on the age and the fitness of the patient.– Sometimes the patient can be given medication that mimics the effects of exercise.–

During the stress test irregular heartbeats, breathlessness, dizziness, drop or rise in blood pressure or chest pain can occur. The physician has to monitor the electrocardiogram, the blood pressure and the pulse. In addition the stress test must not be performed if the patient suffers from certain diseases like myocardial inflammation, unstable angina pectoris, very high blood pressure at rest or lung edema.

All things considered the ECG is a safe procedure. Although the stress test, which includes stressful exercise, can lead to effects like dysrhythmia and in extremely rare cases heart attack. Important to note is, that those effects are not caused by the Electrocardiograph, but rather by high stress exercise.

Are there ethical issues associated with the topic?

In general, the ECG does not have any ethical issues.

Some people do not want to perform an ECG. One reason can be that those people do not want to know if they have any cardiac diseases. In that case, the dilemma of the physician is to decide whether to accept the decision of the patient or not. It cannot be neglected if the physician is absolutely sure that the patient is suffering from severe cardiac disease.

(A very controversial ethic issue which can be mentioned is also that in some cultures the man is in charge of a woman's decision.)

4. The MEDICAL DEVICE

BTL-08 ECG apparatus

The electrocardiograph records and detects the heart's electrical activity and is used in cardio-diagnostics. The heart produces electrical impulses which spread through the heart muscle to make the heart contract. These impulses are in a range of hundreds of microvolts up to around1 millivolt and can be detected by the ECG machine. The electrocardiograph measures the tiny voltage changes on the skin caused by the depolarisation of the heart muscle during each cardiac action. Therefore the machine has to be very precise. The signals can be transformed to 'waves' and recorded to a paper or computer.

The BTL-08 ECG apparatus offers the possibility to record the ECG graph automatically or manually.

Electrodes

The electrodes are the detectors placed at the patient's body and they are connected to the ECG apparatus with a wire for each electrode. For a conventional 12-leads ECG, 10 electrodes are placed on the patient's chest and limbs. The overall magnitude of the heart's electrical potential is measured from 12 different leads and is recorded over a certain period of time. In our project, we only use 4 limb electrodes with different coloured tongs positioned as followed:

Four limb electrodes with tongs (R, L, F, N) and connected electrode cables

- **R**: (red) right wrist

- **L**: (yellow) left wrist

- **F**: (green) left ankle

- **N**: (black) right ankle

Always keep in mind that R and L refer to R and L OF THE PATIENT.

The computer is connected to the ECG and the software evaluates the recorded signals and transforms it into voltage-time 'wave' diagrams. It provides a detailed analysis, diagnostics and printing of the recorded electrocardiogram. It also offers the possibility to change between automatic and manual measurement.

[[File:ECG apparatus.png]]

[[File:limb electrodes.png]]

[[File:triangle.jpg]]

5. Methodology

Task 1

1. Turn on the computer

2. Open the ECG file and click on the folder of your group

3. Create a *new patient* and fill in the personal data

- in the *ID field* you are supposed to put in your birth number. In case you don't have it, you can put in a not controllable birth number, such as: 010101/999

- in the *Comment* field you should fill in personal information, that could influence the heart rate, such as: smoking, drinking alcohol, doing sports, medication, personal anamnesis and family anamnesis

Plug the cables in the *limb electrodes* (red, yellow, green and black clips) and place them on the cot

4. The examined person lies down and the electrodes get attached on the moistened skin. Red - right wrist, yellow - left wrist, green - left ankle, black - right ankle

5. Turn on the ECG device

6. Start the *New standard ECG examination* (it might take a while, until the signal stabilizes)

7. Check if the parameters are set correctly

- *Time base (posuv)*: usually set at a speed of 25 mm/s but can be increased to 50 mm/s

- *Amplitude (zesílení)*: usually set at 10 mm/mV up and down

- *Filter (filtr)*: 50 Hz

- *Time constant (časová* konstanta)*: choose as long as possible (3.2 s)*

8. Save a 10 sec. period by pressing the *Enter* button. Wait a little and repeat this twice

9. Terminate recording by pressing the *Esc* button

10. Turn off the ECG device and remove the electrodes from the examined person

11. Print the three measurements

- Parameter setting:

- *Grid (mřížka)*: normal

- *Time base (posuv)*: 25 mm/s

- *Amplitude (amplituda)*: long enough so that the graphs do not overlap, usually 10 mm/mV

- *Print leads (tisknout* svody)*: all recorded (usually all)*

- *Wave length (délka* záznamu)*: 5 sec*

- *Diagnosis (diagnóza)*: automatic diagnosis (intervals); approved diagnosis (leave empty)

- *Image export*: not important Graphical interpretation of measurements:

Interpretation of the graphical measurements:

1. Choose one lead (best readable one) for further evaluation

2. Measure individual requested intervals and amplitudes in the printed record, fill in the appropriate report section; careful about units

3. Calculate average R-R interval and heart-rate (frequency) in both required units

4. Draw the lengths of amplitudes of QRS vectors to the scheme of Einthoven triangle; using these projections in individual leads draw the vector of the electric axis of the heart (example given in Figure below)

5. Evaluate amplitude [mV] and slope [º] of the axis vector from the drawing

6. Compare the results to those of automatic evaluation and discuss the possible differences and the method itself.

Task 2

1. Attach the electrodes to examined person as in Task 1

2. Turn on the ECG device

3. Start the *New long ECG examination*

4. Choose lead II and set the interval for 3 min.

5. The examined person needs to breathe in consistently for 5 sec and then breathes out for another 5 sec. Inhaling and exhaling phases should be announced by the examiner, in order that the „patient“ can relax and the ECG can record the heart rate according to the respiration. DO NOT EXAMINE AN EPILEPTIC PERSON!

6. Wait until the signal stabilizes

7. Start the ECG with the *Enter* button; heart in the lower right corner turns red, showing that the measurement has started

8. If the time is up, the ECG window will automatically close

9. Turn off the ECG device and remove the electrodes from the examined person

10. Print the measurements (one recorded minute on each sheet)

6. Conclusion

What are the possible impacts on medicine?

The first heart rhythm measurements were made at the end of the 18th century. In 1984 the international society for computerized Electrocardiology (ISCE) was founded with the aim of uniting academia, industry, physicians and patients. Therefore they invite every year for their Annual conference scientists, clinicians, engineers and policy makers to discuss the newest developments in cardiology. If we hadn’t societies which care about the future like the ISCE does, today’s cardiology would not be that successful in diagnosing heart rhythm abnormalities, infarctions et cetera and millions of lives could be lost.

What future developments are envisaged in the area?

At the moment a new ECG machine is being discussed and developed, called “CombynTM Function and Spaces-ECG“, with which it will be possible to diagnose several diseases in only three minutes whilst the expensive time of doctors and patients will be reduced. In addition, illnesses like cardiac insufficiency or the state of the aorta, oedema (accumulation of water) and the mass of muscles can be diagnosed via this new technique.

NEW VIDEOTUTORIAL (in Czech with English subtitles):

https://www.youtube.com/watch?v=wwINxDnFUjw

References:

http://www.isce.org

http://steiermark.orf.at/news/stories/2742996/

https://de.wikipedia.org/wiki/Elektrokardiogramm

Mayo Clinic