304.2 - Medical data science
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Informatique et systèmes de communication ISC
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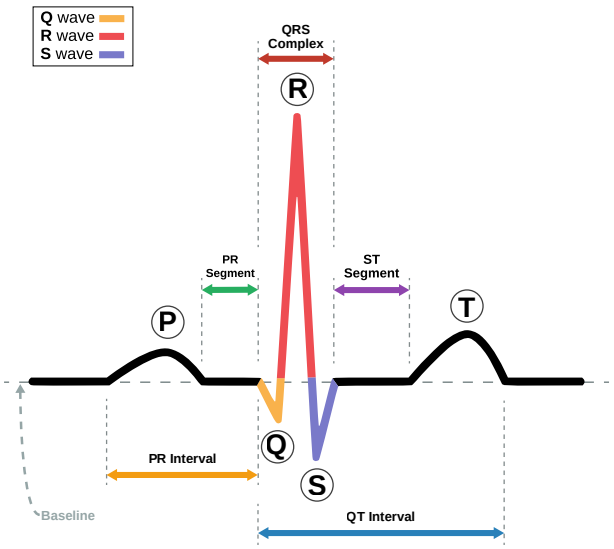

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Rapport de projet pour la filière ISC

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L. Christen

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1 – Introduction

This document will outline how the heart works and attempt to explain what happens between the biological phenomenon of beating and the pixels displayed on a cardiologist's screen.

2 – How the heart works

This section will detail the "macro" and "micro" functioning of the heart

2.1 – Micro

The heart functions like an electromechanical pump whose efficiency depends on a perfectly coordinated sequence of electrical activation. Each heartbeat is triggered by successive changes in the electrical state of the cells, a process called depolarization and repolarization.

At rest, cardiac cells, or cardiomyocytes, maintain a negative membrane potential, with the interior of the cell being negatively charged relative to the exterior. This polarization is the result of an uneven distribution of ions on either side of the plasma membrane, maintained by active pumps. Depolarization corresponds to the loss of this membrane polarization, initiated by the opening of specific ion channels.

This change in charge creates a microcurrent that spreads from cell to cell via communicating junctions, causing a coordinated contraction, known as systole. Once the contraction is complete, the heart must prepare for the next beat through repolarization.

2.2 – Macro

The synchronization of the chambers is ensured by an intrinsic electrical network. The impulse originates in the sinus node, located in the right atrium, which acts as the heart's natural pacemaker. The signal first spreads through the atria (P wave), then reaches the atrioventricular node (AVN). The AVN plays a crucial role as a timer, slowing down the impulse to allow the ventricles to fill before contracting.

After passing through the AV node, the impulse travels simultaneously through both ventricles via the bundle of His, its right and left branches, and finally the Purkinje network. This rapid distribution ensures powerful and effective ventricular contraction, resulting in the QRS complex on the screen.

Phase of the cardiac cycle	**Electrical phenomenon**	**ECG translation**
Atrial activation	Bi-atrial depolarization	P wave
Conduction delay	Passage through the AV node and bundle of His	PR interval
Ventricular activation	Biventricular depolarization	QRS complex
Ventricular rest	Ventricular repolarization	T wave

Table 1 - Heart cycle

3 – Signal acquisition

The electrical signal from the heart, carried by ions in the body, must be converted into an electronic current in order to be processed by the electrocardiograph. This critical step takes place at the interface between the skin and the electrode.

3.1 – Mechanism of the Ag/AgCl electrode

The silver chloride (Ag/AgCl) electrode is the universal standard due to its non-polarizable properties. Unlike polarizable electrodes, which act as capacitors and block direct current, Ag/AgCl electrodes allow for smooth charge transfer via reversible redox reactions.
However, a half-cell potential of approximately 220 mV to 300 mV develops systematically, creating a continuous offset (DC offset) that the device's electronics must manage, as it is much greater than the cardiac signal itself (approximately 1 mV).

3.2 – Signal acquisition and conditioning electronics

Between the electrode and the screen, the signal undergoes a series of electronic transformations designed to amplify the cardiac component while eliminating massive environmental noise.

These transformations are inherent to the device used. At this stage, we are unable to explain them clearly. The D-Heart device documentation, once acquired, will allow us to know which part of the noise is removed electronically or on device and which part will need to be removed by the software.

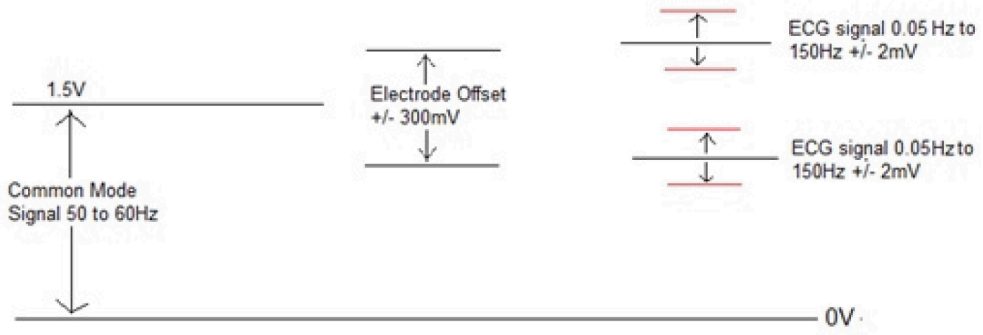

Figure 1 - Characteristics of the ECG signal to be acquired. (www.eetimes.com)

4 – D-Heart device

The D-Heart device has 6 electrodes and can obtain a total of 8 leads. With this, we should be able to detect cardiac abnormalities, sleep apnea, and sleep cycles.

5 – Sources

- L’activité électrique du coeur
- Dépolarisation
- Electrodes
- Deepl
- Gemini
- Signal noise

List of Figures