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VISIÓN ELECTRÓNICA

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VISIÓN ELECTRÓNICA

Analysis of Heart Rate Variability in Dilated Ventricular Cardiomyopathy

Análisis de la Variabilidad de la Frecuencia Cardíaca en la Miocardiopatía Ventricular Dilatada

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Abstract

A case study of dilated ventricular cardiomyopathy (DCM) is performed. Pathology is known as a disease of the heart muscle in which there is evidence of left, right or biventricular ventricular dilatation and systolic dysfunction in the absence of hypertension, coronary artery disease or valvular heart disease to justify it. In addition, ventricular dilatation and resulting systolic dysfunction can lead to congestive heart failure. This means that the heart cannot pump enough blood to meet the body's needs, causing symptoms such as fatigue, shortness of breath, fluid accumulation in the tissues and general weakness. MVD can increase the risk of developing cardiac arrhythmias, such as irregular or rapid heartbeats, due to the altered electrical structure and function of the heart. Furthermore, detection of the main causes is challenging due to

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geographic variability, incomplete penetrance of the disease, or late onset of presentation. However, it is possible to find a correlation of parameters extracted from an ECG (Electrocardiogram) in relation to heart rate variability (HRV) as a determinant in the identification of the pathology.

The main causes and risk factors that generate MVD are related to genetic predisposition, viral infections, excessive alcohol consumption, drug abuse and autoimmune diseases. In addition, some risk factors include family history of cardiomyopathy, arterial hypertension, coronary artery disease and obesity. Therefore, treatment of the pathology usually includes medication for symptom control, but in more severe cases, it may be necessary to consider a pacemaker or cardiac transplantation. For the study performed, a 47-year-old test subject was taken, who has a subdermal pacemaker, given that he has eccentric left ventricular hypertrophy with severely decreased ventricular systolic function, aortic and mitral sclerosis with moderate insufficiency, and even severe biauricular dilatation with dysfunction.

Thus, to recognize and diagnose MVD in a shorter time, HRV analysis is performed, allowing the collection of features that enable the acquisition of a pattern given by the nature of the disease. Additionally, as a future work, it is expected to submit these features to artificial intelligence algorithms to evaluate the possibility of diagnosing MVD by extracting ECG features.

Keywords: ECG, Cardiomyopathy, Heart Rate Variability.

Resumen

Se presenta un caso clínico de miocardiopatía ventricular dilatada (MCD). Se trata de una enfermedad del músculo cardiaco en la que hay evidencia de dilatación ventricular izquierda, derecha o biventricular y disfunción sistólica en ausencia de hipertensión, arteriopatía coronaria o valvulopatía que la justifiquen. Además, la dilatación ventricular y la disfunción

sistólica resultante pueden provocar insuficiencia cardíaca congestiva. Esto significa que el corazón no puede bombear suficiente sangre para satisfacer las necesidades del organismo, lo que provoca síntomas como fatiga, dificultad para respirar, acumulación de líquido en los tejidos y debilidad general. La ECM puede aumentar el riesgo de desarrollar arritmias cardiacas, como latidos irregulares o rápidos, debido a la alteración de la estructura eléctrica y el funcionamiento del corazón. Además, la detección de las causas principales es un reto debido a la variabilidad geográfica, la penetrancia incompleta de la enfermedad o el inicio tardío de su presentación. Sin embargo, es posible encontrar una correlación de los parámetros extraídos de un ECG (Electrocardiograma) en relación con la variabilidad de la frecuencia cardiaca (VFC) como factor determinante en la identificación de la patología.

Las principales causas y factores de riesgo que generan MVD están relacionados con la predisposición genética, las infecciones víricas, el consumo excesivo de alcohol, el abuso de drogas y las enfermedades autoinmunes. Además, algunos factores de riesgo incluyen antecedentes familiares de miocardiopatía, hipertensión arterial, enfermedad coronaria y obesidad. Por lo tanto, el tratamiento de la patología suele incluir medicación para el control de los síntomas, pero en los casos más graves puede ser necesario plantearse un marcapasos o un trasplante cardíaco. Para el estudio realizado se tomó un sujeto de 47 años, portador de un marcapasos subdérmico, dado que presenta hipertrofia ventricular izquierda excéntrica con disminución severa de la función sistólica ventricular, esclerosis aórtica y mitral con insuficiencia moderada, e incluso dilatación biauricular severa con disfunción.

Así, para reconocer y diagnosticar la MVD en un menor tiempo, se realiza un análisis de la VFC que permite recoger características que permiten adquirir un patrón dado por la naturaleza de la enfermedad. Además, como trabajo futuro, se espera someter estas características a algoritmos de inteligencia artificial para evaluar la posibilidad de diagnosticar la MVD mediante la extracción de características del ECG.

Palabras clave: ECG, Cardiomiopatía, Variabilidad de la Frecuencia Cardíaca.

1. Introduction

Currently, cardiovascular problems are one of the main reasons for death in the world. When we talk about cardiac surgeries and coronary procedures, we must mention that for many years it was an elusive topic for health sciences, it was until the 20th century where the first achievements were made, turning the heart into an object of study, and technological advances in medicine, so much so that heart transplants that were not even contemplated before, are now one of the greatest advances in the world. Receiving a donated heart can be a difficult task, involving many years of waiting. Since, naturally the heart must be donated by someone who is clinically dead but remains on life support. The donated heart must be in normal condition, free of diseases, and be as compatible as possible with your blood and/or tissue type to reduce the likelihood that the body will reject it. The heart is one of the most important organisms in humans. We are talking about a muscle that is responsible for pumping blood rich in oxygen and nutrients to the body's tissues through blood vessels, a vital function to stay alive. It is precisely the muscle that works the most in the human body. The heart beats approximately 115,000 times a day, at a frequency of 80 times per minute and 42 million times a year, which is equivalent to hard work. The heart is made up of two layers of muscle, the thin outer layer of the heart is the pericardium, while the inner layer is defined as the endocardium. It is divided into four chambers, two upper and two lower, in the upper chambers are the atria that receive the blood that enters the heart, and in the lower chambers are the ventricles that expel the blood. Between the chambers there are heart valves that open and close, keeping the blood moving. Dilated ventricular cardiomyopathy (DVM) is known as a disease of the heart muscle in which the presence of left ventricular or biventricular dilation and left systolic dysfunction is evident in the absence of hypertension, coronary artery disease or valvular disease that justifies it [1]. Detection of the main causes of MVD represents a challenge for medicine, due to geographical variability, incomplete penetrance of the disease or late onset of its presentation, as well as changes in diagnostic criteria [2], which It affects approximately 1 in 250 people and worldwide around 20 million people are diagnosed with this pathology [3-5]. The classification of MVD can vary between medical organizations, being divided into genetic, mixed or acquired by the American Heart Association, and into familial (genetic) or non-familial (non-genetic) by the European Society of Cardiology [6-7]. The World Health Organization (WHO) considers MVD to be a serious cardiac disorder with abnormalities in the heart muscle that can cause major complications, such as heart failure and arrhythmias, leading to significant morbidity and mortality [8].

1.1. Global distribution of MVD behavior

In Figure 1, you can see the global sample of the annual percentage variation in the number of deaths per 100,000 people, due to cardiomyopathy or myocarditis. The included data includes all ages and both sexes in an observation window between 1990 and 2019. Although, a decrease in birth rates can be observed due to MVD due to the medical procedures applied, as well as the correct medication. However, the increase in deaths in some places is not clear. Critical data can be seen in South America, Asia, North Africa and part of Europe, the data is taken from https://vizhub.healthdata.org/gbd-compare, consulted on September 10, 2023.

Considering the affected world population and the visualized challenges of the pathology; The causes and characteristic patterns of the disease became an interest for biomedical engineering, which seeks to find potential causal variables of the pathology, based on a case study of a subject with MVD related to a viral infection. This research presents a compilation of determining data for the extraction of HRV parameters for the recognition of the behavior of the ECG signal in the case study. Likewise, this article is subdivided into ten different sections: summary, introduction, bibliometric review, methodological design, case description, parameterization, application and conclusions.

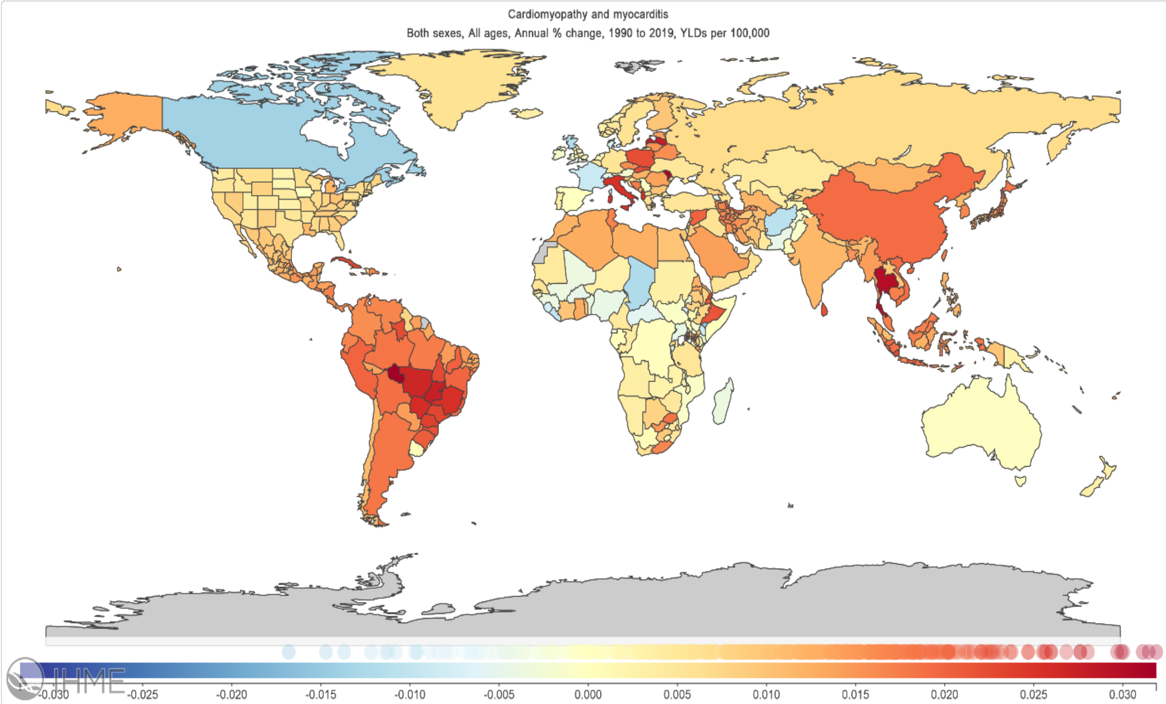

Figure 1. Global description of the behavior of cardiomyopathy. [8]

2. Bibliometric Review

The bibliometric review is based on the analysis of the state of the art, based on the projects documented in the literature, emphasizing the analysis of dilated ventricular cardiomyopathy. Using VOSviewer, a bibliometric map is created, allowing the trends of the research of interest to be analyzed and visualized. The scientific literature used to create the map has been extracted from databases such as: Scopus, IEEE Explore, Science Direct, Google Scholar.

Below is the general bibliometric map of the study carried out (Figure 2), thanks to this the generalized referrals in the literature for the analysis of dilated ventricular cardiomyopathy are known. This map exemplifies the correlation between the articles investigated, indicating that the topics most frequently found are: cardiomyopathy, cardiac dysfunction, case study, electrocardiography. From the bibliometric study carried out, it is evident that the topic has been little developed by research groups in the area, which determines that it can contribute to the area of rehabilitation engineering and clinical engineering.

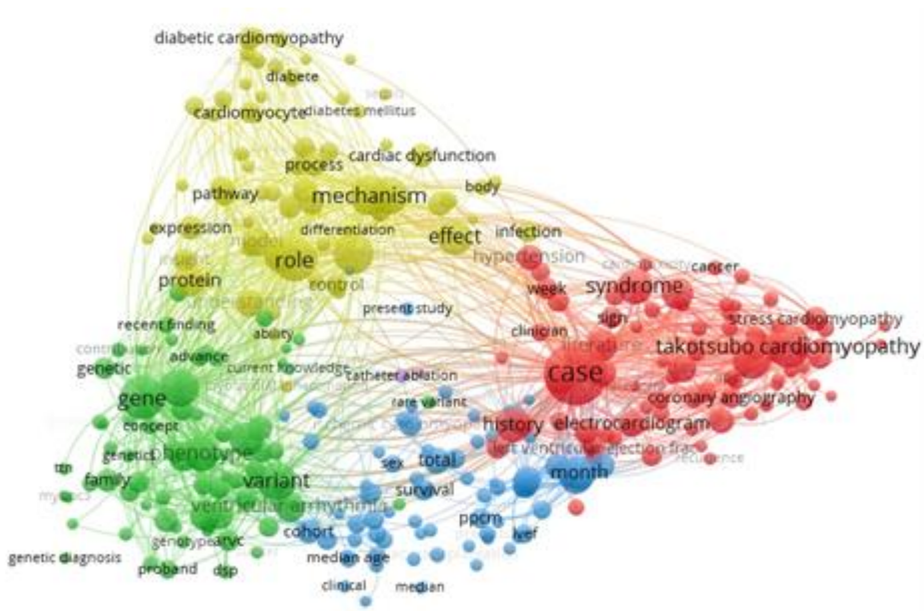

Figure 2. General bibliometric map of the MCV study. Source: own.

Therefore, the systematic review carried out through a PRISMA (Preferred Reporting for Systematic Reviews and MetaAnalyses) type flowchart is critically evaluated, in order to identify future research priorities, address questions found, evaluate methodologies and terminologies that allow describing and studying the problem to be solved. This diagram (Table 1) is characterized by its division into three parts:

Identification: Previous studies described in the selected scientific literature are identified, consequently, a search algorithm is generated, minimizing and highlighting general aspects required for the research.

Screening: Refers to the selection made after identification, criteria are proposed that allow us to recognize and reject documents that do not generate interest in the research.

Inclusion: Documentation chosen for its content for the purpose of the investigation.

For the inclusion and exclusion of scientific documentation, the following search criteria were used:

- Search algorithm: “study AND myocardiopathy AND cardiac dysfunction AND motor rehabilitation”.

- Inclusion of articles with publication date: from 2015 to 2023. Exclusion of repeated articles
- Exclusion of articles that deal with heart diseases.
- Exclusion of articles that do not delve into the study of cardiomyopathies.
- Exclusion of articles that use invasive techniques.
- Exclusion of articles that do not treat cardiomyopathy.
- Exclusion of articles that focus on heart transplants.

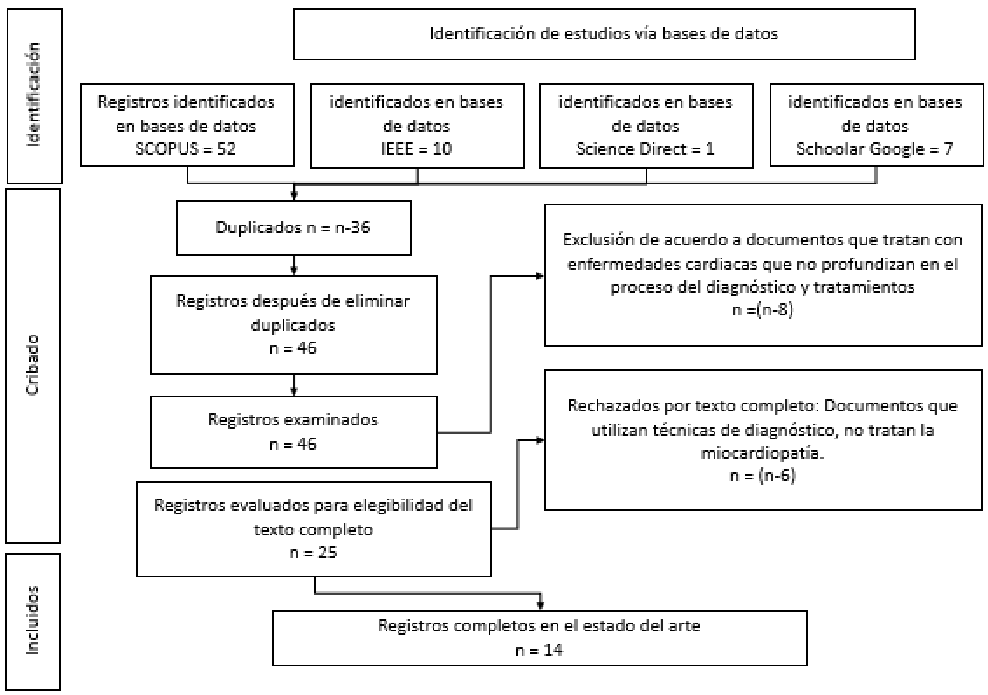

Table 1. PRISMA Diagram. Source: own.

3. Methodological design

In order to determine the correct parameterization of the case study for dilated cardiomyopathy, a broad analysis of characteristics and aspects considered in the methodological development presented in Figure 3 is taken into account, by which four (4) stages are defined that make up the execution and application of the study.

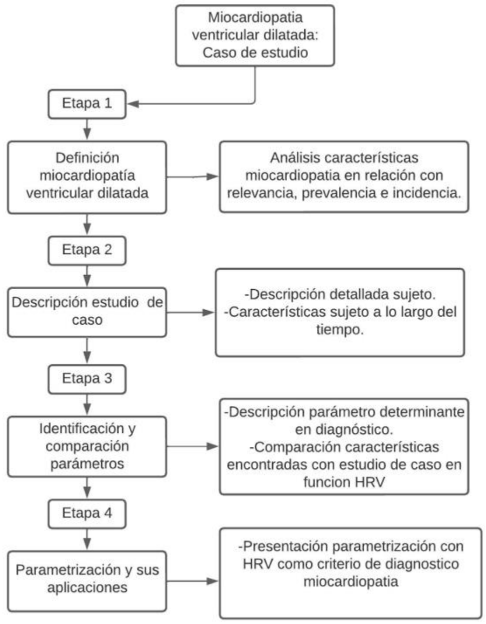

Figure 3. Methodological design. Source: own.

Initially, the definition, prevalence and incidence of dilated ventricular cardiomyopathy are taken into account, with which it is possible to analyze its main characteristics and evaluate the importance of this type of cardiac pathology in the clinical setting (stage 1). Likewise, in stage 2, the case study description is presented based on a detailed description of the subject's condition and the evolution and change of his symptomatic characteristics in relation to his clinical history and electrocardiography examination.

From the detailed description of the symptomatic state and the characteristics of the subject of the case study, it is possible to extract parameters and determining factors for the diagnosis of the pathology (stage 3). In this way, a comparison of these characteristics is also presented in comparison with the aspects identified in subjects with a viral type of diagnostic cause, with which it is possible to verify the identification of the determining factor of diagnosis and in addition, it favors the parameterization and analysis. appropriate case study.

Likewise, in stage 4, based on the comparison and identification of parameters of the study subject in relation to the diagnostic status, the implementation of the parameterization obtained in applications related mainly to the use of artificial intelligence as a support tool is described. diagnosis that focuses on improving the effectiveness and accuracy of the diagnosis of dilated cardiomyopathy.

4. Description of the case

The study is based on a 47-year-old subject with idiopathic dilated ventricular cardiomyopathy diagnosed at age 33 (December 2009). The beginnings of the disease were described by a respiratory infection (flu) that lasted for about 2 months. He was exposed to severe weather conditions, forcing the heart to maintain a higher cardiac output, at a time when he had difficulty breathing, a feeling of suffocation (dyspnea), cough with constant phlegm, disorientation, he went to a fourth level hospital of complexity, where through emergency care a large drop in blood pressure was evident, during observation pulmonary edema (accumulation of fluid in the numerous air sacs of the lungs) was detected, which led to an immediate intervention of a thoracentesis, the fluid was reduced and after 5 days of observation through echocardiograms, dilated ventricular cardiomyopathy was detected, which took the subject to the ICU where an LVEF (Left Ventricular Ejection Fraction) of 20% was evident in the ICU. An experimental test was suggested to increase the contractile force of the heart and its heart rate. The case was based on putting the patient to sleep and disconnecting vital signs for approximately 30 seconds and resuscitating the patient with the defibrillator. After this intervention, the test was successful, achieving an LVEF of 37%.

By May 2020, the subject suffers an ischemic stroke (CVA) derived from a blood clot directly from the heart; At this time the brain tissue dies as a result of an insufficient blood supply. From this accident, the subject loses a serious disability in language and memory. After 7 months of rehabilitation, he can speak normally again. In order to improve heart stimulation and proper functioning, a permanent pacemaker is implanted in the patient in November 2022.

Today, the study subject has recovered LVEF under management to 46%. There is sub-Hisian block, atrial fibrillation, binaural dilation, type II systolic dysfunction, controlled arterial hypertension, stage II chronic kidney disease, ischemic stroke, focus of atrial tachycardia of the pulmonary veins dissociated with right sinus rhythm, Wenckebach phenomenon (Atrioventricular block of grade type I) with spontaneous blocks 2:1 or greater where HIS without conduction is observed.

4.1. Description of study parameters

It is known that Dilated Ventricular Cardiomyopathy due to Viral Infection (IVDI) due to its behavior as it is a cardiac condition where there is a weakening and enlargement of the muscle that directly influences the variation in heart rate, it is for this reason that it is performed. the analysis of heart rate variability (HRV) in order to evaluate multiple fluctuations in the cardiac cycle of an ECG signal and thus extract key parameters to recognize the cardiac behavior of the case under study.

To extract features from the ECG signal, the analysis of heart rate variability (HRV) is performed; from this analysis the following parameters are obtained [14]

- Minimum, maximum and average RR interval
- Minimum, maximum and average heart rate (BPM).
- Heart Rate Variability (SDNN)
- Poincaré indices (SD1, SD2 and SD1/SD2)
- Power within frequency bands (ULF, VLF, LF, HF and LF_HF)
- Number of RR intervals with a difference in duration from the previous one of less than 20 and 50 milliseconds (NN20, NN50).

- Percentage value of the number of RR intervals with a difference in duration from the previous one of less than 20 and 50 milliseconds (pNN20, pNN50)

The expected values for ECG parameters in a person with IVCM:

- Minimum RR interval: Variable (the heart is beating irregularly), but generally less than 600 milliseconds, maximum variable, but generally greater than 1200 milliseconds, and medium variable, but generally greater than 900 milliseconds.
- Minimum heart rate: Variable, but generally less than 50 beats per minute, maximum variable, but generally greater than 100 beats per minute variable average, but generally greater than 75 beats per minute.
- Heart rate variability: Variable, but generally reduced, this indicates that the heart is not responding appropriately to changes in the body. In a study published in the Journal of the American College of Cardiology in 2011, IVCM patients had a mean SDNN value of 20 ms, which is significantly lower than the value seen in healthy people (50 ms).

In another study published in Heart in 2000, IVCM patients had a mean SDNN value of 15 ms, which is also significantly lower than the value seen in healthy people.

- The Poincaré Indices are described as follows, SD1 is a measure of short-term heart rate variability, SD2 is a measure of long-term heart rate variability, SD1/SD2 is a measure of the ratio between short-term heart rate variability and long-term heart rate variability.

In a study published in the Journal of the American College of Cardiology in 2011, IVCM patients had a mean SD1 of 20 ms, a mean SD2 of 50 ms, and a mean SD1/SD2 of 0.4. These values are significantly lower than the values observed in healthy people.

In another study published in Heart in 2000, IVCM patients had a mean SD1 of 15 ms, a mean SD2 of 40 ms, and a mean SD1/SD2 of 0.3. These values are also significantly lower than the values observed in healthy people.

- Power within the frequency bands (ULF, VLF, LF, HF, and LF_HF): Variable, but generally altered. This indicates that the heart is not functioning normally. In a study published in the Journal of the American College of Cardiology in 2011, patients with IVCM had a mean ULF power of 20 μV^2, a mean VLF power of 50 μV^2, a mean LF power of 100 μV^2 and an average HF power of 300 μV^2
- These values are significantly lower than the values observed in healthy people.

In another study published in Heart in 2000, patients with viral IVCM had a mean ULF power of 15 μV^2, a mean VLF power of 30 μV^2, a mean LF power of 50 μV^2, and a mean HF power of 200 μV^2

These values are also significantly lower than the values observed in healthy people.

- Number of RR intervals with a difference in duration from the previous one of less than 20 and 50 milliseconds: Variable, but in general greater than in a healthy person. The number of RR intervals with a difference in duration compared to the previous one greater than in a healthy person indicates that the heart is beating irregularly. In a study published in the Journal of the American College of Cardiology in 2011, patients with IVCM had an average number of RR intervals with a duration difference from the previous one less than 20 milliseconds out of 50, and an average number of RR intervals with a duration difference from the previous one less than 50 milliseconds out of 100. These values are significantly greater than the values observed in healthy people.

In another study published in Heart in 2000, patients with IVCM had a mean number of RR intervals with a difference in duration from the previous one less than 20 milliseconds out of 40, and a mean number of RR intervals with a difference in duration from the previous less than to 50 milliseconds from 80. These values are also significantly higher than the values observed in healthy people.

- Percentage value of a number of RR intervals with a difference in duration from the previous one of less than 20 and 50 milliseconds: Variable, but generally greater than in a healthy person, in a study published in the Journal of the American College of Cardiology in 2011, patients with IVCM had a mean percentage value of a number of RR intervals with a difference in duration from the previous one of less than 20 milliseconds of 10%, and a mean percentage value of a number of RR intervals with a difference in duration from the previous one of less than 10%. 50 milliseconds of 20%. These values are significantly higher than the values observed in healthy people.

In another study published in Heart in 2000, patients with viral IVCM had a mean percentage value of a number of RR intervals with a difference in duration from the previous one of less than 20 milliseconds of 8%, and a mean percentage value of a number of RR intervals with a difference in duration from the previous one of less than 50 milliseconds of 15%. These values are also significantly higher than the values observed in healthy people.

To carry out the processing of the ECG signal, the process described by the algorithm is carried out: “Extraction of heart rate variability parameters” carried out in [14]. In order to expose and describe the extraction of signal parameters, this is carried out step by step using an ECG signal obtained from the patient under study.

5. Analysis of the implemented system

For the development of the application, it begins with the choice of packages for signal processing. A package is known as the container of classes that allow the grouping of different parts of a program with common functionality and elements that have the location of said classes defined by a directory with a hierarchical structure. For this process, the following packages are imported:

1. *h5py:* Package used to load data from h5 input file.
2. *Biosignalsnotebook:* Package to upload, plot and process the acquired data.
3. *Numpy:* Package used for numerical calculation and data analysis.

5.1. Uploading acquired ECG data.

The acquired ECG data are characterized by having hierarchy, metadata, sampling rate and resolution, these data are obtained when the signal is taken, therefore, these data are loaded in order to analyze and extract the parameters. These data are:

1. Second level of hierarchy: ['digital', 'events', 'plugin', 'raw', 'support']
2. Metadata: ['channels', 'comments', 'date', 'device', 'device connection', 'device name', 'digital IO', 'duration', 'firmware version', 'keywords', 'macaddress', 'mode', 'nsamples', 'resolution', 'sampling rate', 'sync interval', 'time']
3. Attributes: [Sample Rate, Resolution]
4. Third level of hierarchy obtained using the 'raw' group: ['channel_1', 'channel_2', 'channel_4', ' nSeq ']

In this case, the third level of hierarchy is channel 2.

5.2. Storing sample rate and acquired data within variables.

The sampling rate, the signal sample containing the ECG signal and the time are set; The sampling frequency used is given by the sampling rate, the sample used is the signal generated by the third level of hierarchy, the time is set as the length of the signal over the sampling frequency of the sample.

5.3. Tachogram generation

When you want to carry out the study of cardiac periodicity, you need to obtain an element that is part of all cardiac cycles. The QRS complex is the prominent element to carry out said study. By detecting each R peak, a time interval is determined between each peak which can generate a time series known as a tachogram, that is, a tachogram is the graphic representation of RR intervals (time elapsed between two or more R waves in an ECG) generated consecutively and sequentially describing the change in the period of the cardiac cycle over time, thus generating the basic structure for the extraction of parameters. Through the functions provided by the *Biosignalsnotebook library,* the tachogram is graphed in the desired cardiac cycle. It is also considered that the library automatically performs processing in order to eliminate noise that may affect the tachogram (Figure 4).

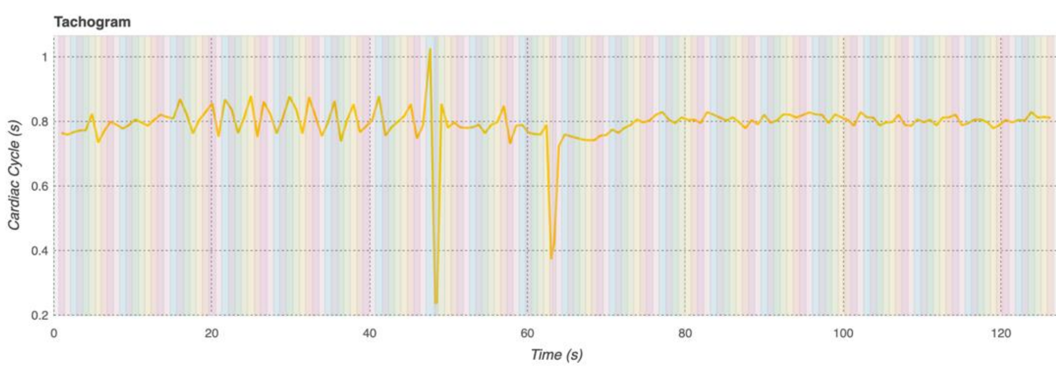

Figure 4. Generation of the tachogram. Source: own.

5.4. Elimination of ectopic beats

Ectopic beats are defined as the cardiac cycle that differs by at least 20% in duration from the previous cycle. These types of beats are subsequently eliminated at this stage of processing. A comparison of the general tachogram made before and after elimination is made. of ectopic beats (Figure 5).

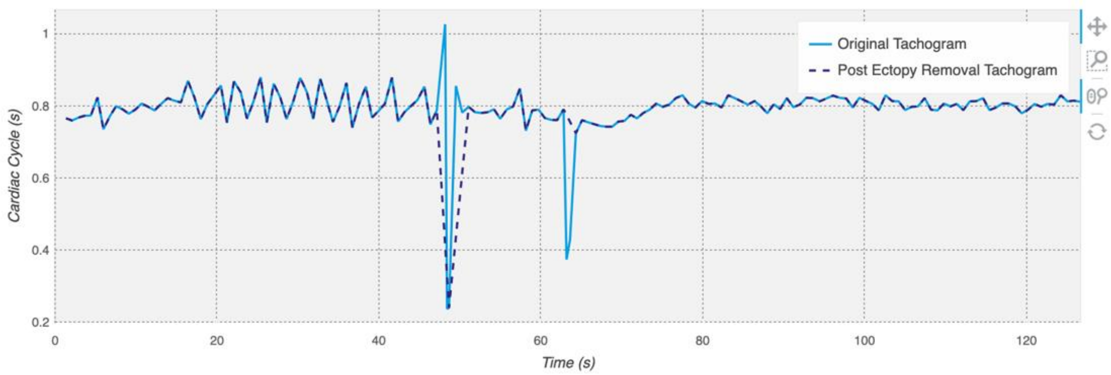

Figure 5. Comparison of tachogram before and after removal of the ectopic heartbeats. Source: own.

5.5. Time parameters

The time parameters are extracted from general characteristics of an ECG such as the RR interval, the heart rate per minute known as BPM and the heart rate variability (SDNN), which is acquired by the standard deviation of the RR interval. For the case study, the values obtained from the time parameters were acquired by capturing the respective drifts of the heart. Figure 6 corresponds to the general graph of the results of these parameters.

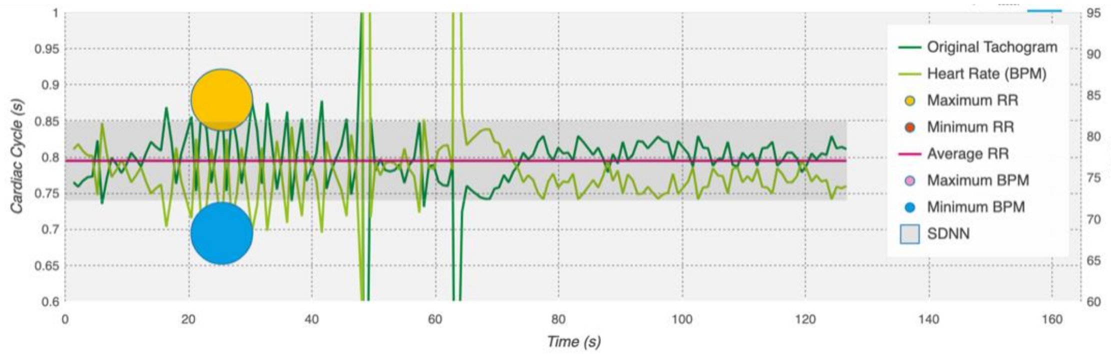

Figure 6. Comparison of tachogram before and after removal of the ectopic heartbeats. Source: own.

5.6. Poincaré parameters

The Poincaré diagram defines a non-linear and geometric treatment of the ECG signal for the study of heart rate variability. This graph is characterized by being two-dimensional, each point is constructed using the tachogram of the signal. The evaluation of the heart rate is visualized by the dispersions of the Poincaré points. If the distention of the points in relation to the lines is high, your heart rate will also be high.

The parameters SD1 and SD2 are responsible for quantifying the level of dispersion with respect to each reference line and are characterized by being proportional in the short (SD1) and long (SD2) term with respect to the variability of heart rate. Also, the relationship between SD1/SD2 is extracted as a parameter. For the case studied, the values obtained from the Poincare parameters are shown in figure 7, which corresponds to the Poincare graph.

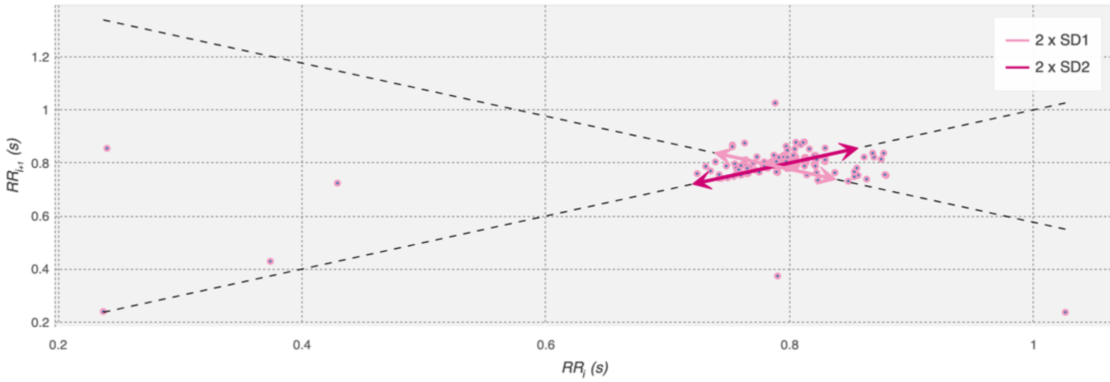

Figure 7. Poincare graph. Source: own.

5.7. Power Parameters

The frequency parameters correspond to the band components extracted from the frequency domain and offer information about the sympathetic and parasympathetic attributes in the control of heart rate variability of the ECG signal, these are: ULF, VLF associated to harmonic signal components characterized by their low frequencies and LF, HF associated with autonomous segments of heart rate variability. The increase in cardiac variability is proportional to the increase in the power value. For this example, the values obtained from the power parameters are presented in Figure 8, which corresponds to the power graph.

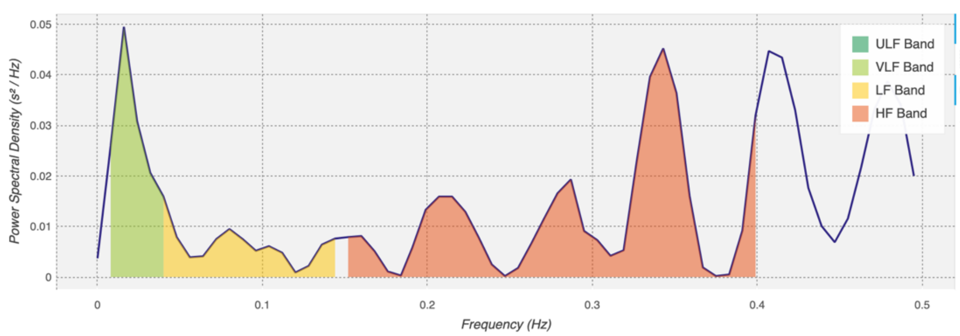

Figure 8. Poincare graph. Source: own.

5.8. Additional temporal parameters studied

As temporal parameters, the number of RR intervals with a duration difference from the previous one of less than 20 and 50 milliseconds (NN20, NN50) is extracted, together with the percentage value of the number of RR intervals with a duration difference from the previous one of less than 20 and 50 milliseconds. (pNN20, pNN50). In this case, the values obtained from the additional temporal parameters are shown in Table 2.

HRV parameters	Test 1	Test 2	Test 3	Average
MaxRR [s]	0.9080069	0.87900691	0.869006	0.88533994
MinRR [s]	0.71400543	0.24000189	0.698005	0,55067077
AvgRR [s]	0,80515519	0,79479196	0,797401	0,79911605
MaxBPM [BPM]	84,0329746	249,998035	85,95927	139,99676
MinBPM [BPM]	66,0787928	68,258849	69,04438	67,7940073
AvgBPM [BPM]	74,5197955	75,4914529	75,24444	75,0852295
SDNN [s]	0,03276484	0,05435902	0,031396	0,03950662
SD1 [s]	0,02624814	0,07025352	0,024316	0,04027255
SD2 [s]	0,03818513	0,03121295	0,03715	0,03551603
SD1/SD2 [s]	0,68739155	2,25078102	0,654542	1,19757152
NN20	62	69	69	66,6666667
pNN20 [%]	38	43	40	40,3333333
NN50	22	33	32	29
pNN50 [%]	13	20	18	17
ULF_Power [s^2]	0	0	0	0
VLF_Power [s^2]	0,00043	0,00102	0,00018	0,00054333
LF_Power [s^2]	0,00008	0,00062	0,00006	0,00025333
HF_Power [s^2]	0,00012	0,00289	0,00037	0,00112667
LF_HF_Ratio [s^2]	0.66666667	0.21453287	0.162162	0.34778718
Total_Power [s^2]	0.00063	0.00453	0.00061	0.00192333

Table 2. Parameters studied. Source: own.

6. Conclusions

Through the analysis of Heart Rate Variability (HRV), it is possible to extract crucial parameters for the evaluation of Dilated Ventricular Cardiomyopathy (DVCM), allowing relevant information to be obtained for the diagnosis and monitoring of the disease. By applying the elimination of ectopic beats, the signal is characterized to mitigate the noise obtained in the acquisition of the tachogram. With the processed signal, it is possible to determine the parameters over time with which a characterization of the characteristics of interest is achieved, as seen in Figure 6. With the classification of the Poincare and power parameters, the differences in the intervals can be highlighted. HR Finally, by relating the parameterization used, the characteristics of the pathology are obtained in terms of the average of the categorical variables, which will allow the development of an early diagnosis system.

It is expected as future work to implement an application based on artificial intelligence to diagnose MVDIV by extracting features based on HRV, which were obtained in the present work and from ECG signals. This, to significantly speed up and improve the diagnosis process.

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