

A Review of Heart Rate Variability and its Applications

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Abstract— Heart rate variability (HRV) is a dependable reflection of the numerous physiological factors tweaking the ordinary mood of the heart. Actually, they give a intense methods for watching the interaction between the thoughtful and parasympathetic sensory systems. It demonstrates that the structure producing the signal isn't just essentially direct, yet additionally includes nonlinear commitments. Heart rate (HR) is a non-stationary signal; its variety may contain symbol of diseases, or notices about looming cardiovascular sicknesses. The symbol might be occur consistently or may happen at arbitrary—amid specific interims of the day. It is strenuous and tedious to study and pinpoint variations from the norm in voluminous information gathered more than a few hours. Subsequently, HR variety examination (immediate HR against time pivot) has turned into a famous noninvasive device for surveying the exercises of the autonomic sensory system. PC based explanatory devices for top to bottom investigation of information over daylong interims can be extremely valuable in diagnostics. Hence, the HRV signal parameters, separated and dissected utilizing PCs, are exceedingly valuable in diagnostics.

I. INTRODUCTION

Heart is an important part of the human body. Heart diseases are the important factor which cause of death in the world. Heart diseases are not a disorder but these are the group of diseases which occur in the heart and in which the heart supplying to blood are blemish and not able to do work properly in a normal manner. For many years, it was believed that heart diseases only occur as age increases or simply to say that the tendency of diseases is more in older people. But now days, heart diseases are common in young people also, because of their lifestyle and devour habits. Heart diseases usually take many years to be cured.

There are different types of heart defects present in teenagers, which are called congenital heart diseases. Other types of heart disease consist of coronary heart disease, hypertension, stroke, arrhythmia and cardiac disease. The most common cause of heart diseases is atherosclerosis and hypertension means high blood pressure. Atherosclerosis is a condition in which there is deposition of cholesterol and fatty substances on the walls of arteries, while hypertension is the elevation of blood pressure in the arteries due to various reasons. There are different parameters that raise the risk of heart diseases and related conditions. These consist of age, gender, high blood pressure, high cholesterol levels and mental stress. Parameters like weight, blood pressure and cholesterol levels can be restrained by making proper diet and lifestyle changes to significantly improve cardiovascular health.

The use of the heart is to contract systematically and pump blood to the lungs for oxygenation and then pump this blood into the whole body. This electrical activity is transmitted throughout

the body and can be monitored at the skin and can help predict many heart disorders. This is the principle behind ECG (Electrocardiogram).

The potential difference between two points on the outer portion of the body is traced to get the ECG chart. There are two different measuring points between the left arm and the right arm. The two points and setting up the conventional positive direction for measuring the voltage called a Lead. There are 12 electrodes are used to measure the potential difference which are placed to outer surface of the body .

Tests after tests show that the most suitable alternative for the development and assessment of ECG is the three channels CSE database, although it can only be used for assessments of one channel accuracy[1]. In order to accurately determine the ECG of an individual, several aspects are put into consideration. One of them is the HRV or Heart Rate Variability, which refers to the variation between the normal heart rate and a given mean value.

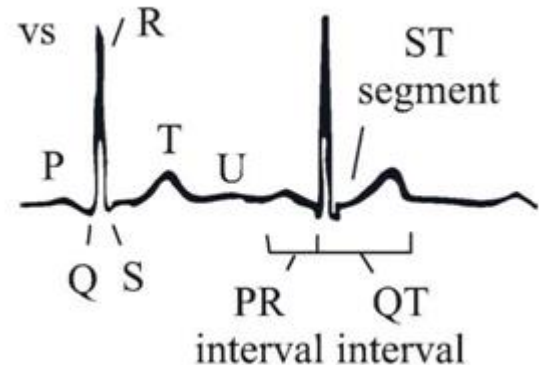


Fig. 1 Heart Wave Signal

The heart rate may vary but may result from diabetes complications, fetal distress in a pregnant mother, and congestive heart failure. One thing worth noting is that HRV is useful in predicting myocardial infarction. A reduced HRV is symptomatic of this condition which if left untreated is usually fatal.

II. METHODS

A) HRV Analysis Methods

The first thing to note is that HRV methods for analysis of heart rhythms, do not generally involve opening up the body and physically examining the heart. Usually, doctors employ

three different methods namely, the Non Linear, time domain, and frequency domain methods. Even with these methods, one ought to consider various factors such as the individual in question's health status, respiration, gender and age. Others parameters that generally influenced HRV tests were abnormalities in the Sympathetic nervous System (SNS) and Parasympathetic nervous system (PNS). There are three states of HRV signals are compared: anger, relaxation, and appreciation. Once again, the tachograms are displayed, along with power spectra analyses, derived from the tachogram patterns. Short term power spectra analyses produce peaks or clusters of data points mostly within three main regions[2]:

High Frequency (HF) from 0.15 Hz to 0.40 Hz reflects the activity of the parasympathetic system and the vagus nerve.

Low Frequency (LF) from 0.04 Hz to 0.15 Hz reflects sympathetic activity.

Very Low Frequency (VLF) from 0.003 Hz to 0.04 Hz reflects a host of factors, including not only the sympathetic nervous system, but also input from chemoreceptors, thermoreceptors, the renin angiotensin system and others.

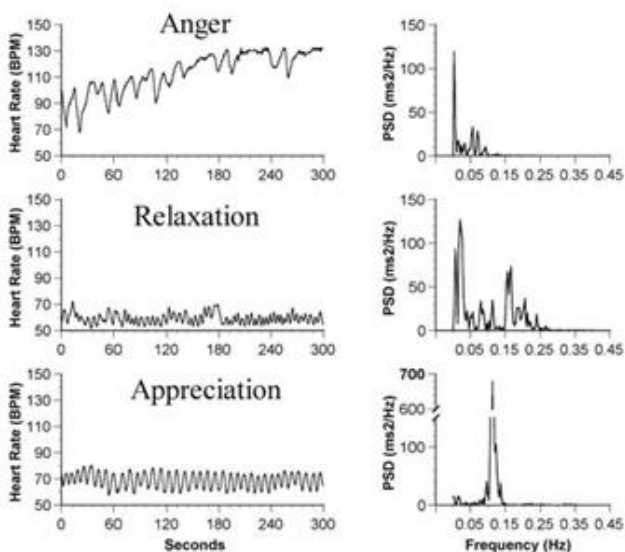


Fig. 2 Anger, relaxation, and appreciation signals

According to most research journals, the most frequently used technique for HRV is the linear technique, specifically Spectral Analysis. In this method, spectral power in a high frequency band is employed to reflect respiratory sinus arrhythmias while at the same time, a low frequency reflects baro-receptors control. Very low frequency power on the other hand shows the vascular and thermo-regulatory functions of the heart[3].

B) HRV Analysis Methods

Heart rate variation techniques and indexes have proved crucial in treating not just cardiovascular system diseases,

but unrelated conditions such as stroke, Alzheimer, renal failure, leukemia, epilepsy, chronic migraines, and obstructive sleep apnea. Most doctors tend to agree that all biological systems, even the healthy ones tend to show haphazard dynamics while biological systems suffering from disease show reduced levels of dynamics. Since all organs depend on the flow of blood from the heart, any cardiovascular abnormalities will affect all other organs and affect the heart rate activity. That said, autonomic dysfunction is a key characteristic of heart and diseases such as sepsis, brain trauma, multiple organ failure, and myocardial infarction. Other conditions that show high HRV indices include Congestive Heart Block (CHB), Left Branch Bundle Block (LBBB), Sick Sinus Syndrome (SSS) and Premature Ventricular Contraction (PVC).

As said before, Heart Rate Variability is affected by Sympathetic and Parasympathetic system disorders, but those of the peripheral nervous and the central nervous systems also play a major role[3].

C) HRV Analysis of ANS Dysfunction

A Power spectral analysis of HR for hypothyroid displays certain key features in patients with hypothyroidism. They include autonomic dysfunction with a higher level of vagal tone, change in the metabolism of some of the amines in the brain, and reduced parasympathetic activity with increased t_3 and t_4 . Therefore, any change in the thyroid hormone causes a change in the heart rate activity.

Simply put, a thyroid that is not working well by either under producing or overproducing hormones bears negative effects on the heart. The physical manifestation of a poorly functioning thyroid is a rise in the blood pressure and hypertension of the arteries. A non-linear analysis method to check for heart rate variability showed a value for CD of slightly over 5 for an individual with hypothyroidism. This is in comparison to the 6.42 figure needed for a healthy individual. A reduced CD reading is regarded by physicians as a sign of reduced tolerance to cardiovascular (heart) stress. The relationship between the thyroid hormones is best seen with regard to the sympatho-vagal balance, which shows an ECG reading of 5 minutes [4].

D) HRV Analysis of Depression

For a long time, researchers have known that ANS deregulation causes death from heart disease and HRV analysis, which provides information about the ANS in various ailments. HRV methods possess the ability to show the amount of dysfunction in ANS, brought about by psychiatric disorders such as depression and schizophrenia. To some people, depression is not a psychiatric disorder; however, when it reaches chronic levels, it is harmful to the cardiovascular system. Results from several studies show that ANS dysfunction is one of the markers for depression. In the case of depression, HRV measures cardiac autonomic innervations of the brain, which will eventually result to

coronary artery disease and myocardial infarction. Some scientists postulate that a reduction in parasympathetic nerves allows the unopposed stimulation, which could lead to an irregular heartbeat and even death. Scientists also note that in chronic sympathetic stimulation, major depression occurs side by side with severe neuropathy. In the case of subjects with major depression, heart rate variation methods using frequency domain provide more accurate results. They include non-linear correlation methods, frequency domain methods, and time domain methods. Regardless of the test used, a very severe depressive illness will always show a change in the heart rate activity [5].

III. HEART RATE VARIABILITY AND ITS APPLICATIONS

A) NON-LINEAR METHODS AND APPLICATIONS FOR ARRHYTHMIA ANALYSIS

Traditional methods and indices lack the ability to unearth the fine changes in the heart rate activity because it is not stationary. That means in plain terms that fluids constantly move from one body organ to the next, through arteries and veins. This is of course can only happen if the individual is alive. A nonlinear deterministic method seems like being more appropriate in explaining more complicated phenomena, indicating that evidently; erratic behavior is capable being created even through a simple deterministic system that has nonlinear structure[6].

The cardiovascular system is very complex to be of a linear nature, so the only way one can understand the HRV is by using predominantly nonlinear methodologies. For HRV analysis of Arrhythmia, a medical practitioner must adopt a concept based on rapid fluctuations that may show changes in sympathetic and vagal activity [7].

They contain indicators of current HRV behavior or evidence of future medical conditions. For instance, the DFA method or Adopted Detrended Fluctuation Analysis can quantitatively and qualitatively study abnormalities of the heart rhythm[8].

B) INTERPRETATION OF THE ECG SIGNALS AND GRAPHS

The ECG graph is a printout designed to show the electrical activity in the form of waves occurring in the heart muscle. To plot this wave, it is important that one understands a number of technical terms like the QT interval, which is between depolarization of the ventricles and the end of the depolarization. The QRS complex and the T wave represent depolarization and re-polarization respectively.

The QT interval assessment method consists of QRS complex detection and T wave offset. The key to interpreting QT interval assessment is the initial detection of characteristic points. It is vital that QRS complex markers be made available. The assessment begins by splitting the main signal into single heartbeats and detecting the individual points separately. The individual doing the

assessment must detect and identify the onset peaks and offset of the P wave. Then the onsets and offsets from different channels must be combined leading to a single onset and offset for P, QRS and T per beat[9].

In single wave detection, the QRS onset detection exists as well. The QRS onset detection requires the filtering of a signal using a 60 Hz low pass filter, which modulates the signal within a short time window. Detection of the exact point desired to show heart rate variation is done by systematically decreasing the threshold value. A calculation to show the possible onset point and the mean range is determined, such that the point with the lowest ratio in between the mean values is chosen as the exact onset point.

One must compare the value of the margin by calculating the following parameters: the gradient of the descending wave with respect to that of the ascending wave, the stability of the signal outside of the wave, and the distance between the preceding and subsequent extremum. Other things to calculate and consider are the amplitude of the wave and the high bypass cut off frequency [10].

IV. CONCLUSION

Heart rate variability investigation has turned into an essential tool in cardiology, since its estimations are noninvasive and simple to perform, have moderately great reproducibility and give prognostic data on patients with heart ailment. HRV has turned out to be a profitable tool to explore the thoughtful and parasympathetic capacity of the ANS, particularly in diabetic what's more, postinfarction patients. Unearthly examination of HR has clarified the idea of diabetic autonomic neuropathy what's more, of other neurologic issue that experience the ANS. Nonlinear parameters can be utilized to examine the strength of the subjects. Later on, singular treatment changes in accordance with go for the most ideal sympatheticparasympathetic balance in postinfarction patients may be conceivable with the assistance of HRV examination.

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