Morphological Changes in Congestive Heart Failure ECG

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***Abstract*—Heart failure is a multi-faceted syndrome with diverse etiologies. Cognition of the movement can be crucial to therapy. The overall occurrence of heart failure is likely to increase in the future because of both an aging population and remedial advances in the supervision of acute myocardial infarction important to improved survival in patients with impaired cardiac function.ECG is the major source for diagnosis the congestive heart failure. In this paper the some morphological features of ECG are extracted from healthy and heart failure persons to find out the changes in features. 10 healthy ECG and 10 cardiomyopathy effected ECG are included in this study. The features are extracted from these ECGs signals. The hypothesis test is used in these ECGs features to compare normal and heart failure ECGs. The result of this method shows that the morphological changes are strongly significant in the ECG of CHF (Congestive Heart failure).**

Keywords: ECG, Wavelet transform, Hypothesis test, MITBIH, Congestive heart failure

I. INTRODUCTION

One of the major causes of morbidity and mortality in all over the world is Congestive heart failure (CHF). As the population ages, its prevalence are rising despite improvements in medical therapies and surgical techniques. Despite numerous recent advances in the field of medicine, congestive heart failure (CHF) has been difficult to manage with in clinical practice and mortality rate has stayed high [1] [2].

Pump failure is a clinical syndrome which is due to the inability of the pump to eject or fill blood at a consistent rate with the need of the metabolizing tissues. Pump failure is also due to abnormality of cardiac structure [3]. Pump failure is a common and major health problem worldwide that continues to increase in both prevalence and incidence. It is a frequent cause for hospitalization. It is a multi-faceted syndrome with diverse etiologies [4]. Knowledge of the cause can be crucial to therapy. Enhancing the dependability of determination has been key following deciding the etiology and the phase of the heart disappointment prompts diverse administration decisions to enhance manifestations, quality of life and disease prognosis.

The ideal ECG waveform of the human heart is shown in Fig. 1. The morphology of electrocardiogram ECG is widely used in cardiology for the diagnosis of cardiovascular diseases because of its effectiveness and low cost procedure [6]. The

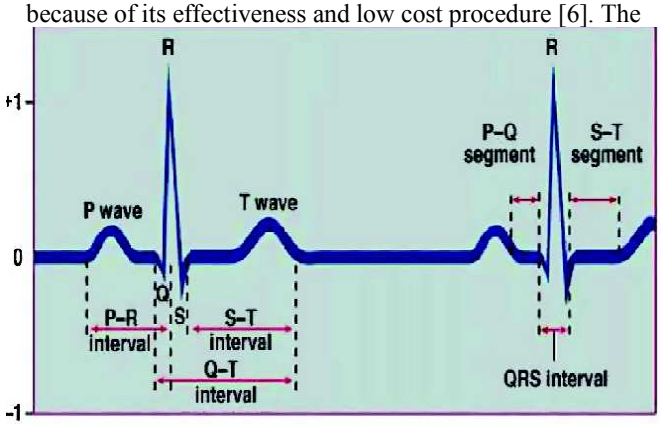

Figure 1: ECG waveform [7]

ECG is a graphic record of the direction and magnitude of the electrical activity that is generated by depolarization and repolarization of the atria and ventricles. In a normal ECG heartbeat there are five prominent points [7].The inaugural is the P wave and corresponds to an atrial depolarization. This happens after the sinoatrial (SA) node generates an impulse. The node is located in the right atrium. The second is the QRS complex and corresponds to atrial repolarization and ventricular depolarization. By this time the ventricular excitation is complete. There is then a ventricular repolarization through the T wave. P waves the adequacy level of this voltage signal wave is low (approximately 1 mV and the right and left atria depolarization and contraction is represented by P wave. A clear P wave before the QRS complex speaks to sinus rhythm. Absence of P waves may recommend atrial fibrillation, junctional beat or ventricular pulse. It is exceptionally hard to investigate P waves with a high signal to noise ratio of ECG signals. The QRS complex is the biggest voltage redirection of roughly 10-20 mV yet may shift in size contingent upon age, and sexual orientation. The information about the heart disease can be also provided by the voltage amplitude of QRS complex.

Chandrakar Kamath [8] analysis the ECG time series to classify the normal and CHF subjects. Heather J. Shenkman et al. [9] analysis the QRS complex variation in heart failure population. Eduard Shantsila [10] explained that the person with atrial fibrillation associated with high risk of heart failure.

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In this paper the morphological features of CHF and normal ECG are extracted using wavelet transform and find out the feature those show the significant changes in CHF with respect to normal ECG using hypothesis test. These results provide the convenience for a doctor to diagnose the possibility of heart failure.

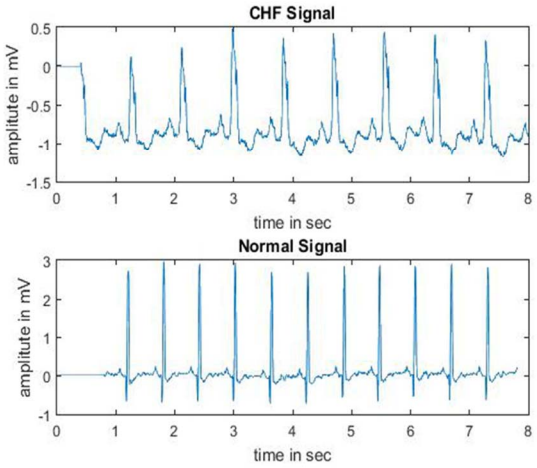

Figure 2: CHF and Normal signal

II. DATABASE

All the ECG records which are used in this study are taken from the benchmark PhysioNet databases. The work includes 10 ECG records from ordinary sinus beat (MIT-BIH typical sinus cadence (NSR) database-nsrdb) [11] [12] and ECG records of 10 subjects with serious CHF (NYHA class 34) from BIDMC congestive heart disappointment (CHF) database-chfdb [13]. The sampling frequency of CHF signal is 250Hz and normal signal is 128Hz.This CHF database incorporates long term ECG recordings from 10 subjects (matured 54 to 63) with extreme congestive heart disappointment (NYHA class 34). This group of subjects was a piece of a bigger study bunch getting ordinary medical treatment preceding accepting the oral inotropic specialists, milrinone. The congestive heart failure and normal signal are shown in Fig. 2.

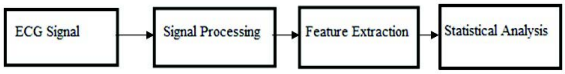

Figure 3: Block Diagram of Process.

III. METHOD

The process of this study is shown in Fig. 3. Raw data is taken from the MIT-BIH database. In signal processing the noise is removed which introduce at the time of ECG fetching. Morphological ECG features are extracted from ECG using wavelet transform. The features which are used in this study are shown in table I. The statistical analysis of data is done with hypothesis test. The two tailed t-test is used to check whether the assumed hypothesis is correct or not. Results are presented by means and standard deviation (SD). A 5% significance level was chosen using two sided tests.

Table I
Features of ECG

S.No	Feature's symbol	Feature description	Unit
1	Q wave	Time duration of Q wave	sec
2	S wave	Time duration of S wave	sec
3	T wave	Time duration of T wave	sec
4	QR slope	The slope between Q and R	degree
5	RS slope	The slope between R and S	degree
6	PR Interval	Time duration between P and R	sec
7	QT Interval	Time duration between Q and T	sec
8	ST Interval	Time duration between S and T	sec
9	Height of QR	Amplitude of QR in QRS complex	mV
10	Height of RS	Amplitude of RS in QRS complex	mV

A. Hypothesis test

A hypothesis test is a statistical test that is utilized to figure out if there is sufficient proof in a sample of information to construe that a specific condition is valid for the whole population. A theory test looks at two restricting theories around a population: the null hypothesis H_0 and alternative hypothesis H_a. The invalid speculation is the announcement being tried. Typically the invalid speculation is an announcement of "no impact" or "no distinction". The alternative theory is the statement user need to have the capacity to finish up is valid.

The rejection of the null hypothesis is based on the testing of sample data. The p-value is compared with level of significance. If the p-value is not exactly or equivalent to the level of significance, which is a cut-off point that is defined by the user, then null hypothesis can be rejected.

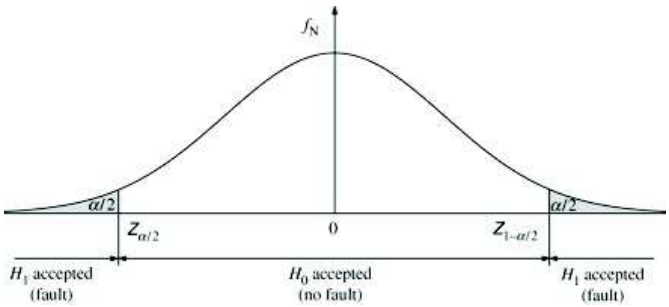

Figure 4: Rejection and acceptance region for two tail test.

In this study two tailed t- test is used (Fig. 4). When the direction of the relationship that user hypothesized is possible to both side then two tailed test is used. One tailed test is used when one side direction is considered and other side is totally ignored. The formula of t-test is given as

$$t = \frac{\bar{X} - \mu_{H_0}}{\sigma_s/\sqrt{n}} \quad (1)$$

where

$$\sigma_s = \sqrt{\frac{(X_i - \bar{X})^2}{(n-1)}} \quad (2)$$

n=number of samples

$\bar{X}$=mean of samples

i=1, 2, 3.....n

μ_{H_0}=null hypothesis mean

Hypothesis testing is use to determine the probability that assumed hypothesis is true. There are four steps which are consisting in hypothesis testing.

1. Define the null hypothesis and alternative hypothesis.
2. Classify a test statistics that can be used to assess the truth of the null hypothesis.
3. Calculate the P-value, the minimum p-value provides the stronger evidence against the null hypothesis.
4. Then compare the p-value with acceptable significance value.

IV. RESULT AND DISCUSSION

To test for statistical significance of the sequential spectrum approach, first analysis the features of ECG data from normal and CHF subjects. The results of these features are shown in table II. The value of features is presented on Mean $\pm$Standard deviation. It shows that the duration of Q, S wave, PR, QT, ST interval and height of QR feature has strongly significant changes because the P value of t-test is less than 0.01. T wave duration and height of RS segment has moderately significant changes due to p value occurs in between 0.01 to 0.05. The slope of QR and RS segment has no any strong or moderate changes. This means if the patient's ECG has these types of changes the possibility of heart failure is high.

The P wave is a little redirection wave that speaks to atrial depolarization. Depolarization of the inter-ventricular septum is related to small Q wave. Q waves can likewise identify with breathing and are for the most part little and slight. The R wave reflects depolarization of the fundamental mass of the ventricles thus it is the biggest wave. The final depolarization of ventricles is represented by the S wave at the base of the heart. ST interval mirrors the time of zero potential between ventricular depolarization and repolarization. S wave reflects last depolariszation of ventricles and T wave speaks to the ventricular repolarization. The ECG can uncover a few distinctive heart issues that can bring about heart disappointment, including heart assaults, beat issue, long-standing strain on the heart from hypertension, and certain valve issues. So that these changes which come on this study can give the information about the heart failure ECG. The results show that if these features are not ideal then it can be due to congestive heart failure. This study also shows that the slope of QRS complex has not a big change.

Table II
Statistical Results of ECG Features

ECG Feature	Normal ECG	CHF ECG	P value
Q wave	0.067 ± 0.013	0.086 ± 0.025	$P < 0.01$
S wave	0.063 ± 0.019	0.111 ± 0.025	$P < 0.01$
T wave	0.024 ± 0.013	0.036 ± 0.018	$0.01 < P \leq 0.05$
QR slope	84.18 ± 4.303	81.33 ± 6.201	$P > 0.1$
RS slope	-86.49 ± 2.02	-82.28 ± 5.634	$P > 0.1$
PR Interval	0.091 ± 0.049	0.184 ± 0.063	$P < 0.01$
QT Interval	0.245 ± 0.048	0.355 ± 0.029	$P < 0.01$
ST Interval	0.111 ± 0.061	0.078 ± 0.038	$P < 0.01$
Height of QR	1.330 ± 0.455	1.611 ± 1.108	$P < 0.01$
Height of RS	1.456 ± 0.441	2.095 ± 1.834	$0.01 < P \leq 0.05$

Mean $\pm$ SD (Standard Deviation)
P value: $0.05 < P \leq 0.10$=suggestive significant
P value: $0.01 < P \leq 0.05$=moderately significant
P value:$P \leq 0.01$ =strongly significant

V. CONCLUSION

The result of statistical analysis shows out of ten features six features have strongly significant changes. The features which are related to duration like Q wave duration, PR interval etc. Have significant changes. This duration of these features is increased in congestive heart failure ECG. This increased duration proves that the functionality of the cardiomyopathy affected heart is going slow. The pumping process of CHF affected heart is slower than normal heart. Another thing the amplitude of the wave has moderate (height of RS) and significant changes (height of QR) is shown in this study. This is very helpful to detect disease in patients. We can classify the CHF ECG from other different type of ECG using these variations of features. Which is helpful for a doctor to diagnose the heart failure from the patient's ECG.

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