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Study And Analysis Of Brugada Syndrome Ecg Pattern

Anita.P.B[1], Prof.ChannappaBhyri[2]
[1]PG Student, PDACE, Kalaburgi,
[2]Prof. Dept of Instrumentation Technology, PDACE, Kalaburgi,

Abstract:

The Brugada syndrome[1] has been gained wide recognition throughout the world and today it is believed to be responsible for 4% to 12% of all sudden deaths and ≈20% of deaths in patients with structurally normal hearts. The leading cause of death of men under the age of 50 in regions of the world where the inherited syndrome is endemic. The syndrome is characterized electrocardiographically by an ST-segment elevation in the precordial leads (V1 - V3) and a rapid polymorphic ventricular tachycardia that can degenerate into ventricular fibrillation. This study has therefore been carried out to detect the abnormality in ST segment of ECG signal which causes brugada syndrome. FFT and WINDOW technique are the ways, which provide the ST segment value.

Keywords: **ECG signal, FFT, feature extraction, WINDOW technique, TWA, FBW, R peak detection, ST segment, MATLAB**

I. INTRODUCTION

Electrocardiography (ECG) is the process of recording the electrical activity of the heart over a period of time using electrodes placed on a patient's body. These electrodes detect the tiny electrical changes on the skin that arise from the heart muscle depolarizing during each heart beat. It is a graphical recording or display of time variant voltages produced by myocardium during cardiac cycle**.** A typical ECG tracing of a normal heart beat (or cardiac cycle) consists of a P wave, a QRS complex and a T wave. P, QRS and T waves reflects the rhythmic electrical depolarization and repolarization of myocardium associated with the contractions of the atria and ventricles. The electrocardiogram is used clinically in diagnosing various diseases and conditions associated with the heart.

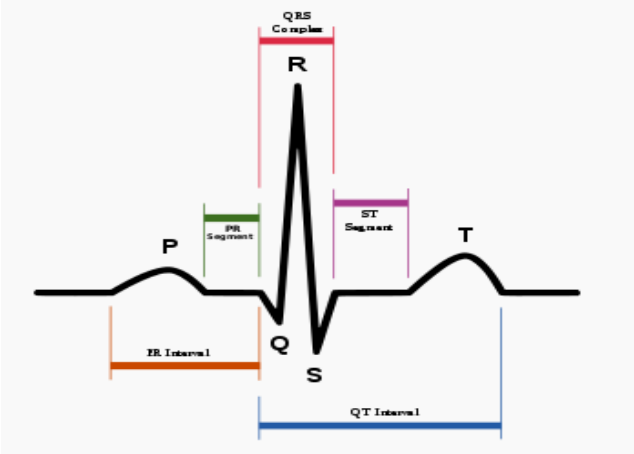

Figure 1:Typical ECG waveform

Waves and Intervals

P wave is caused by atrial depolarization, It is usually a smooth and positive wave, and its duration is normally less than 0.12 seconds. PR interval is the portion of the ECG waveform beginning from P wave (onset of atrial depolarization) to the beginning of the QRS complex (onset of ventricular depolarization), It is normally 0.12 - 0.20 seconds. PR segment is the portion on the ECG wavefrom where the P wave ends to the beginning of the QRS complex. The PR segment corresponds to the time between the ends of atrial depolarization to the onset of ventricular depolarization. It is an isoelectric segment, during which the impulses travel from the AV node through the conducting tissue (bundle branches, and Purkinje fibers) towards the ventricles. QRS complex represents the time taken for depolarization of the ventricles. The normal QRS interval range is 0.09seconds measured from the first deflection to the end of the QRS complex. ST Segment represents the period of ventricular muscle contraction before the repolarization, this segment is normally an isoelectric (no electrical activity is recorded). However, the ventricles are contracting. The QT interval begins at the onset of the QRS complex to the end of the T wave, It represents the time of ventricular depolarization until ventricular repolarization. T wave is formed due to ventricular repolarization and the wave is found normally rounded and positive.

Waves	Amplitude(mv)
P wave	0.25 mv
R wave	1.60 mv
Q wave	25% of R wave
T wave	0.1 to 0.5 mv

Table 1: ECG peak amplitudes

Intervals	Durations(seconds)
PR interval	0.12 to 0.20 s
QT interval	0.35 to 0.44 s
ST interval	0.05 to 0.15 s
P wave interval	<= 0.12 s
QRS interval	0.09 s

Table 2: ECG intervals

Analysis of ECG signal is important to analyze the normal condition of heart. The objective of this work is to carry out automatic analysis of ECG signal for detecting brugada syndrome. Brugada syndrome is a heart rhythm disorder. Each beat of our heart is triggered by an electrical impulse generated by a special cells in the right upper chamber of heart. Tiny pores, called channels, on each of these cells direct this electrical activity, which makes the heart beat. Cause for brugada syndrome is, our heart requires that electrical signal to be sent through the specialized electrical tissues and through the heart muscle called myocardium. This electrical tissue will be able to conduct the electricity because of special molecules called ion channels, these ion channels allow positive and negatively charged particles to pass through the cell walls, this defect is seen in SCN5A ion channel. Brugada syndrome is caused by mutation in one of the several gene, the most commonly mutated gene in this condition is SCN5A[3], which is altered in approximately 30 percent of affected individuals. This gene provide instructions for making a sodium channel, which normally transport positively charged sodium atoms(ions) into heart muscle cells. This type of ion channel plays a critical role in maintaining the hearts normal rhythm, mutation in the SCN5A gene alter the function of the channel which reduces the flow of the sodium ions into the cells. A disruption in an ion transport alters the way of the heart beat, which leads to the abnormal heart rhythm which is characterstics of brugada syndrome, this defect can lead to dangerous heart rhythm called ventricular fibrillation, it is much faster, chaotic heart beat, which may sometimes reach upto 300 beats per minute. chaotic heart beat means very little blood is pumped from heart to the brain and other parts of the body.

Brugada syndrome refer to microvolt change in T wave alteration (MBS), it is an non-invasive heart test that can identify patients who are at increased risk of sudden cardiac deaths. It is most often used in patients who have myocardial infractions (heart attacks) or with other heart problems, to see if they are at high risk of developing a potentially lethal cardiac arrhythmia. Those who are found to be at high risk would therefore be benefited by the placement of an defibrillator device which can stop an arrhythmia and save the patient's life.

II. DIAGNOSIS

Three subtypes have been recognised, based on different ECG features:

i) **Type 1**: Cove-shaped ST elevation in the right precordial leads with J wave or ST elevation value ≥ 2mm (mV) at its peak is followed by a negative T wave with little or no isoelectric interval in more than one right precordial leads V1-V3.

ii) **Type 2**: The ST segments also have a high take-off but the J amplitude of value ≥2mV gives rise to a gradually descending ST elevation remaining value ≥ 1mV above the baseline followed by a positive or biphasic T wave that may result in a saddle back configuration.

iii) **Type 3**: Right precordial ST elevation of value <1mm of saddle-back type or coved type

III. METHODOLOGY

Introduction To Different Techniques

We analyze three methods for analyzing Brugada Syndrome:

1) ECG pre-processing

2) FFT based Technique

3) Windowing based Technique

Procedure for detecting Brugada syndrome in ECG signal

1. Raw ECG from MIT-BIH arrhythmia database is taken from physionet and is uploaded in matlab
2. Preprocessing to remove artifacts
3. R peak detection by using FFT technique
4. From R peak Traverse Forth and Back, P,Q,S,T peaks are detected respectively
5. T wave alterans by using four beat window method
6. ST segment detection by measuring S offset and T onset.
7. By ST segment values conclude the type of brugada syndrome.

RAW ECG:

The raw ECG from MIT-BIH arrhythmia database is taken from physionet.org and uploaded in matlab. The ECG signal consists of y-axis which represents amplitude and x-axis represents samples. This ECG signal consists of different types of noises namely baseline drift, electrode contact noise ,internal amplifier noise etc.

ECG PRE-PROCESSING

ECG signal from MIT-BIH database is firstly pre-processed with a bandpass filter(0.5-20 Hz) to remove baseline movement and noises. Band pass filter works to screen out frequencies that are too low or too high, giving easy passage only to frequencies within a certain range this is called detrending the signal. This was followed by R peak detection

R PEAK DETECTION

After preprocessing the ECG signal, next step is to detect the R peak[2] in ECG signal. As we can see ECG is a uneven signal. Thus our first step is to straighten it. i.e to remove low frequency component. Here we are using direct fast fourier transform method (FFT), to remove low frequencies and restore ECG with help of inverse fourier transform(iFFT) using Matlab

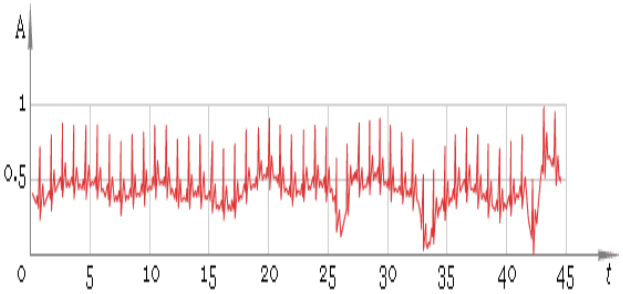

Figure 2: Original ECG signal

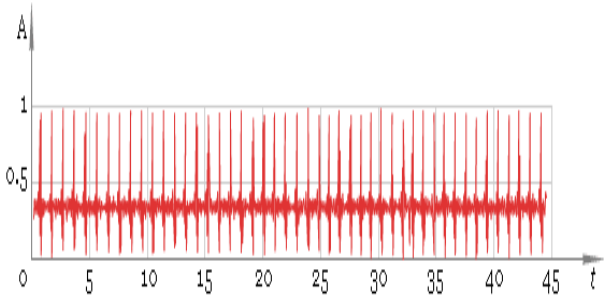

Figure 3: FFT filtered ECG.

second step is to find local maxima value. To do that we use windowed filter that sees only maximum value in its window and ignores all other values. In this step we use window of default size.

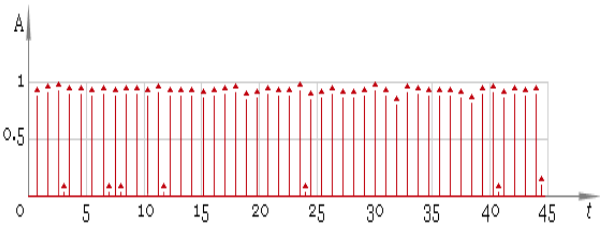

Figure 4: Filtered ECG.

Now we shall remove small values and preserve significant ones. Here we use threshold value.

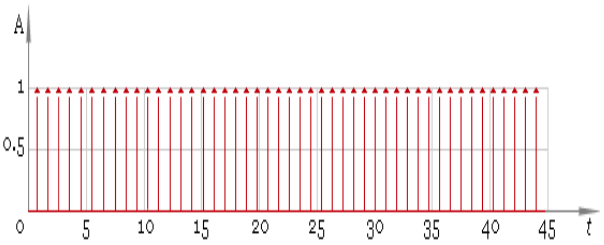

Figure 5: Peaks

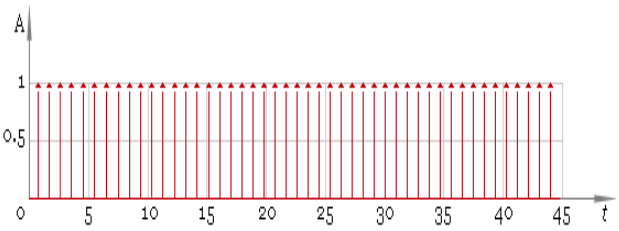

Figure 6: Final result

T Wave Detection

T wave alteration(TWA) [4]is a periodic beat-to-beat variation in the amplitude and shape of the T wave in an electrocardiogram (ECG) signal. The Brugada syndrome test uses an electricardiogram (ECG) measurement of the heart's electrical conduction. The test looks for the presence of repolarisation alteration (Brugada Syndrome) ,which is the variation in the vector and amplitude of the T wave component of the ECG. The amount of variation is very small, it is in the order of microvolts. So sensitive digital signal processing techniques are required to detect brugada syndrome, and T-wave detection is achieved by setting a search window between two R-waves and finding the highest point. The onset and offset of the T-wave were found by

working backwards and forward from the R-wave peak to a point of inflection.

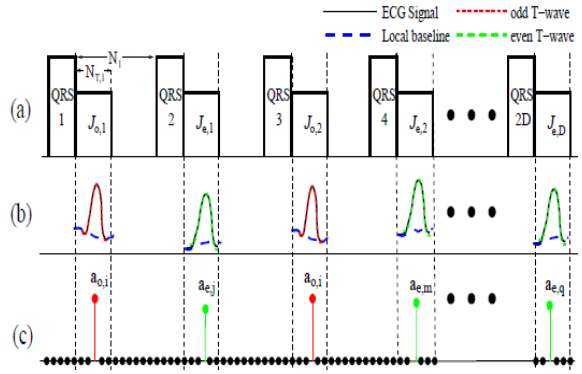

Figure 7: T wave 2D processing window and its amplitude

a. T wave search intervals within the 2D beat processing window
b. T wave within each QRS region
c. T wave amplitude

FBW method the four-beat window was classified as containing alternans according to the Figure below, which shows the logical condition to be satisfied for classification. A data set is classified as BS if more than 5% of window is contained with alternans.

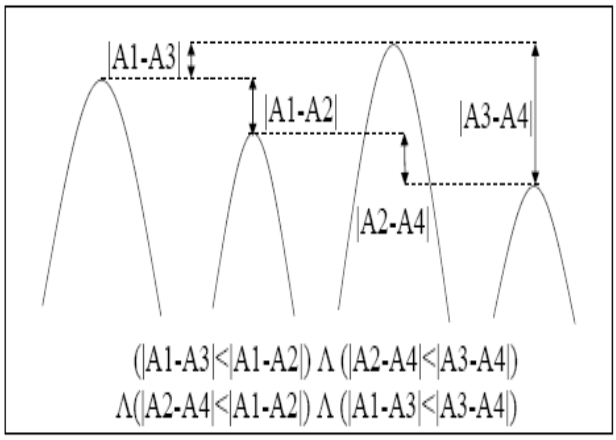

Figure 8: Window Method

BS determination rules for FBW method. where A1, A2, A3 and A4 are the T-wave amplitudes calculated from beat 1, 2, 3 and 4 within the four-beat window.

ST Segment Detection

ST segment[5] is obtained by calculating offset of S and onset of T, this is ST segment, it should be techniquely almost flat, and suddenly the T wave should rise. This is known as elevation. If the wave is below the zero axis line then it is ST segment depression. If we find out ST segment, then we can find elevation and depression.

We got the value of Soff and Ton, Soff(1) first offset of S signal and Ton(1) first onset of T signal. Separating ST segment: It is used for detection of type of brugada syndrome. If the T wave has its amplitude equal above and below zero axis line then it is a biphasic signal.

Onset and offset detection: From any peak detection, zero crossing point behind the peak is considered as onset and zero crossing point ahead of the peak will be detected as offset.

IV.BLOCK DIAGRAM

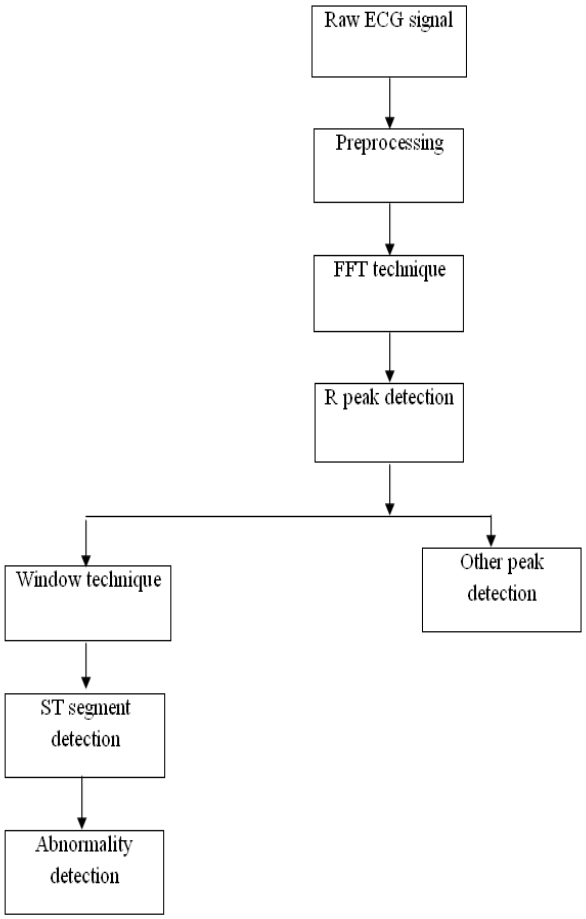

Figure 9: Block diagram

V. RESULTS

Following observation were made from the study of brugada syndrome

1.File name: Twa88m.mat- Normal ECG signal.

Pamp	Ploc	Qamp	Qloc	Ramp	Rloc	Samp	Son	Soff	Tamp	Ton	Toff	Tloc
0.050	307	0.008	334	0.598	354	-0.15	359	380	0.223	407	427	427
0.049	585	0.009	618	0.633	632	-0.16	636	658	0.223	682	702	702
0.049	857	0.008	881	0.621	902	-0.15	906	928	0.222	951	971	971
0.050	1126	0.008	1150	0.607	1172	-0.15	1177	1198	0.223	1223	1243	1243
0.049	1403	0.008	1430	0.618	1450	-0.15	1455	1476	0.222	1502	1522	1522
0.049	1681	0.008	1708	0.614	1727	-0.15	1732	1754	0.224	1778	1798	1798

Table3: Gives amplitude and location of P,Q,R,S,T waves of Normal patient

File name: Twa13m.mat- Type1 Brugada syndrome ECG signal.

Pamp	Ploc	Qamp	Qloc	Ramp	Rloc	Samp	Son	Soff	Tamp	Ton	Toff	Tloc
0.709	103	-0.14	96	1.709	103	0.085	92	113	0.917	155	175	175
0.157	346	-0.15	376	1.861	384	0.094	372	395	0.971	439	459	459
0.158	631	-0.15	659	1.791	667	0.085	656	678	0.921	719	739	739
0.157	903	-0.15	931	1.805	938	0.096	927	948	0.970	989	1009	1009
0.158	1178	-0.15	1207	1.878	1215	0.082	1203	1226	0.920	1271	1291	1291
0.18	1467	-0.15	1497	1.790	1505	0.091	1493	1516	0.972	1560	1580	1580
0.157	1746	-0.15	1772	1.734	1780	0.085	1769	1789	0.921	1827	1847	1847

Table4: Gives amplitude and location of P,Q,R,S,T wave of Type1 brugada syndrome patient.

File name: Twa16m.mat- Type2 Brugada syndrome ECG signal.

Pamp	Ploc	Qamp	Qloc	Ramp	Rloc	Samp	Son	Soff	Tamp	Ton	Toff	Tloc
5.190	30	1.566	69	5.190	94	5.109	98	101	0.325	119	159	159
2.433	1098	1.689	1156	5.314	1181	5.210	1181	1188	0.184	1206	1246	1245

Table5: Gives amplitude and location of P,Q,R,S,T value of 2 samples of a Type2 brugada syndrome patient

File name: Twa89m.mat- Type3 Brugada syndrome ECG signal.

Pamp	Ploc	Qamp	Qloc	Ramp	Rloc	Samp	Son	Soff	Tamp	Ton	Toff	Tloc
0.730	529	539	539	2.730	549	-1.36	557	579	0.040	629	669	649
0.360	1094	1148	1149	2.77	1162	-1.59	1168	1192	0.205	1242	1282	1262
0.349	1401	1455	1455	2.810	1467	-1.27	1475	1497	0.110	1547	1587	1567
0.501	1703	1757	1757	2.745	1769	-1.21	1777	1798	0.059	1849	1889	1869

Table6: Gives amplitude and location of P,Q,R,S,T value of 2 samples of a Type3 brugada syndrome patient

VI. CONCLUSION:

The task of Brugada syndrome detection and complexity index of T wave has been studied in this project in the time domain. In this paper we have obtained T wave alterans(twa) ECG signal from MIT-BIH physionet database. we have tried to remove the noise by bandpass filter, after filteration an algorithm for R peak detection is implemented by FFT technique, finding the values which are greater than threshold value of the actual signal. From R peak traverse forth and back, minima and maxima value is obtained, which is usefull in detecting other peaks such as P,Q,S,T. And further it is passed through the WINDOW technique for detecting T wave alterans, TWA refers to detect the change in shape of T wave. Further Son and Soff period with Ton and Toff periods are calculated and based on that we calculate ST segment. Based on deviation of ST segment, presence of inverted T-Wave can be determined and thus we detect Brugada syndrome. The results are obtained by using matlab, matlab program makes the work much easier and extracted features are situable in detecting patients record with brugada syndrome. There needs to be further work on Brugada Syndrome to standardise Brugada Syndrome quantification methods, especially for features which could relate to cardiac disease. We also show that the FFT based technique is most efficient followed by WINDOW based technique.

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