LAFB, LBBB, RBBB and Myocardial Infarction Detection Using 12 Lead ECG

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Abstract **-** At present time, people die because of the cardiovascular diseases. Myocardial scar, Left bundle branch block (LBBB), Right bundle branch block (RBBB), Left anterior fascicular block (LAFB), Left ventricle hypertrophy (LVH), Right ventricle hypertrophy (RVH) are common cardio diseases. All these diseases lead to the myocardial infarction which is also known as heart attack. For the detection of these diseases a less expensive and accurate tool is required. Electrocardiogram (ECG) indicator can be used as trustworthy pointer of the heart diseases. In this work, we have used 12 lead ECG for the detection of diseases like myocardial scar, LBBB, RBBB and LAFB which leads to heart attack. By using the imaging techniques these diseases can also be detected but the quantification of the scar cannot be identified. But in case of ECG by extracting the features of ECG signal the quantification of the scar can be detected. This quantification gives the percentage of heart damage. To calculate the percentage of heart damage QRS scoring sheet has been used.

All leads of the ECG give the current state of the different regions of the heart hence by detection of abnormalities like notching, slurring and slowing in the 12 different leads of ECG the region of the heart damage has been identified. In most of cases for the extraction of the features of ECG signal discrete wavelet transform (DWT) is used and in case of DWT the number of samples reduces by two after each level of decomposition. In our database the numbers of samples are fewer at the input hence we have used stationary wavelet transform for the extraction of the features of ECG signal.

Keywords - Electrocardiogram, Stationary wavelet transform, Left bundle branch block, Right bundle branch block, Left anterior fascicular block

I. INTRODUCTION

Due to the disable circulation of the blood through the heart muscles results in the death of the some part of the myocardium membrane which is known as myocardial infarction. It is the huge reason behind the deaths because of the cardio problems. This is also known as heart attack. Myocardium is heart muscle which receives the blood supply from the coronary arteries. Blockage of one coronary arteries cause of the heart attack or MI. Due to the shock and hemorrhage the requirement of blood is not fulfilled to the heart. The symptoms for the myocardial infarction are pain in chest that may be the left side of the heart. Left Bundle branch bock, Left anterior fascicular block and Right bundle branch block are the diseases which results the myocardial infarction. By using the ECG or imaging techniques this can be detect [1]. Imaging techniques like Magnetic resonance imaging (MRI), Cardio magnetic resonance are used for the detection of myocardial infarction. But these techniques are not available in all hospitals and are expensive. These are not suitable for the patients who are in the ICU and emergency rooms with cardio problems. If patient have any internal metal rod or clip in the body then that cannot go through the imaging techniques. By using imaging techniques the size of the scar cannot be identified. Electrocardiogram (ECG) is the representation of the electrical activity of the heart muscle as it changes with time. Cardiac muscle contracts and expands in response to electrical depolarization and repolarization. Hence it can be used for the detection of heart diseases like LBBB, RBBB, LAFB, LVH and myocardial scar etc. It is useful for the patients in ICU and for the patients has any metallic rod or chip in the body etc. Electrocardiogram is easy, cost effective and rapid way for the detection of LBBB, RBBB, LAFB and myocardial scar which leads to myocardial infarction and the scar can also be quantify by using the features of ECG signal. By the detection of confounders like slurring, slowing and notching in the different 12 signals of the electrocardiogram the region of heart damage can also be identified. We have less number of samples in our database hence stationary wavelet transform is to be used for the extraction of the features of the Electrocardiogram signals.

In this work, we have used SWT to extract the features of the ECG signal. Mother wavelet used in this work is daubechies wavelet.

A. ABNORMALITIES AND CONFOUNDERS IN ECG CURVE

When there is not any abnormality in the heart it shows that patient have not any heart disease. In this case, the heart rate would be in the range 60bpm-100bpm. This type of ECG is known as .Normal sinus rhythm. In case of the sinus tachycardia there would be the heart rate little fast than the normal and similarly in case of the bradycardia the heart rate would be slow then the normal. Before the contraction of the ventricles or atria they should be completely filled with the

blood. But in some cases, before the fully expansion of atria the contraction of the ventricle exists because of this ventricles does not fully filled with the blood and this type of abnormality is known as premature ventricle contraction. Similarly, if the atria contract before the completely expansion of the ventricles then that type of abnormality is known as premature atria contraction. These are the common abnormalities in the ECG report of the youngsters.

i. LEFT BUNDLE BRANCH BLOCK (LBBB)

Left Bundle Branch block is the type of abnormality in the heart which causes delay in the activation of the left ventricle. In the normal case, both ventricles right and left should be expand and contract at the same time. But because of the left bundle branch block the right ventricle contract earlier then the left ventricle. If a person have QS in the complex or there is notch in V1 and V6 lead then the patient would have LBBB. In this the QRS interval would be more than the normal QRS.

ii. LEFT ANTERIOR FASCICULAR BLOCK (LAFB)

Left ventricle has three type of muscle fibers are known as left anterior muscle fiber, left posterior muscle fiber and septal muscle fiber. In general cases, the posterior and the inferior posterior walls of the left ventricle get supply from the posterior muscle fiber. Anterior fiber give supply to the upper and anterior parts of left ventricle and the septal muscle fiber give supply to the septal wall. Sometimes, posterior part of the ventricle gets supply earlier than the others. Due to this, there would be delay in the depolarization of anterior and upper parts of the left ventricle and this is known as LAFB. Because of this delay QRS axis get widened and shift towards the left axis.

iii. RIGHT BUNDLE BRANCH BLOCK (RBBB)

Generally, right ventricle activate by the impulses in the right ventricle and right bundle branch and left ventricle activate by the impulses in the left bundle branch. But in case of the RBBB, the right ventricle does not activate by the impulses in the right bundle branch but the left ventricle activated by the impulse in the left ventricle branch therefore the impulse would move through left ventricles myocardium and it activate the right ventricle. However the conduction of the right ventricles should be through the purkinje fibers but because of the myocardium membrane it would take the more time and that result in the RBBB. Because of this the duration of QRS will be wider than the normal QRS.

iv. CONFOUNDERS IN ECG

NOTCHING - Notching is defined as a reversal in the QRS trace with an angle > 90◦ and amplitude > 0.05 mV.

SLURRING - Slurs are segments where an ECG signal exhibits minuscule change in amplitude between successive samples, thereby creating a "plateau"-like segment.

SLOWING - It is characterized by an almost smooth declined rate of change in the QRS waveform. Although it is closely similar to slurring, the major difference is that slowing segments have a finite gradient (angle < 90◦) compared to the "plateau"-like nature of slurring.

II. ALGORITHMIC FORMULATION

A. ECG DATABASE COLLECTION

In this research work, we have used the 12 lead ECG real-time databases of the heart patients who have myocardial Infarction problem or any disease which leads to the myocardial infarction. The databases have been collected from the Pawan Cardio hospital, Jalandhar and P.G.I. Chandigarh.

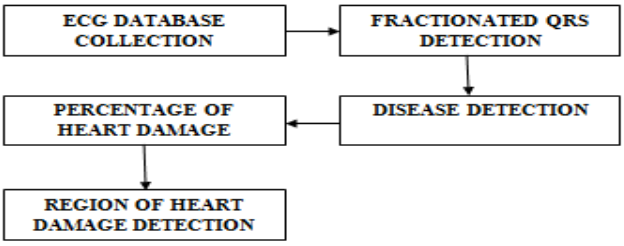

Fig.1: Algorithm process

B. FRACTIONATED QRS DETECTION

i. EXTRACTION OF NOTCHING

Notching is defined as a reversal in the QRS trace with an angle > 90◦ and amplitude > 0.05 mV. In the normal QRS wave, only one maxima minima pair will exist because the change in direction of morphology occurs once. To extract the notching in the detail coefficient space there will be two maxima minima pair with the zero crossing. If the zero crossing point at the 2nd level decomposition and 3rd level decomposition then it means there is valid notch.

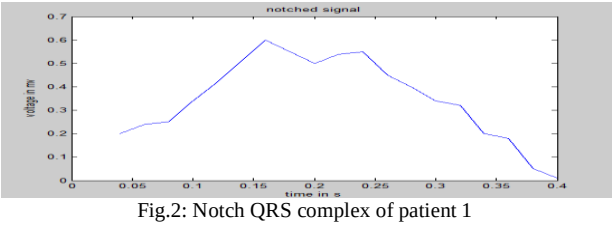

Fig.2: Notch QRS complex of patient 1

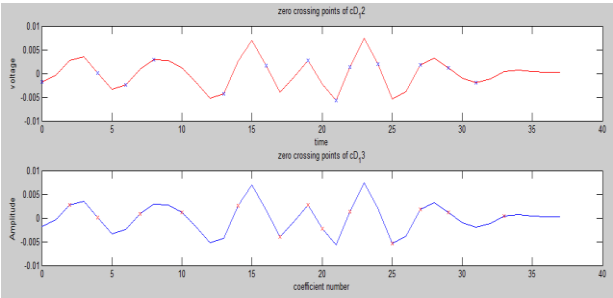

Fig.3: Detection of notch

ii. EXTRACTION OF SLURRING

Slurs are segments where an ECG signal exhibits minuscule change in amplitude between successive samples, thereby creating a "plateau"-like segment.

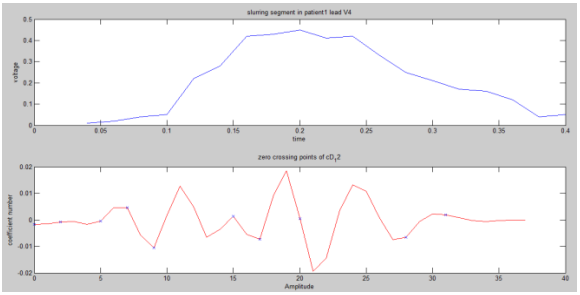

Fig.4: Extraction of slurring

To extract the slurring, we decompose the signal till 2nd level of decomposition. If there are consecutive zeros in the cD_2 then that means there is slurring in the ECG trace. If two or more zeros within 8ms then they consider as the part of same slurring segment.

iii. EXTRACTION OF SLOWING

It is characterized by an almost smooth declined rate of change in the QRS complex of ECG waveform. Although it is closely similar to slurring, the major difference is that slowing segments have a finite gradient (angle < 90◦) compared to the "plateau"-like nature of slurring.

To extract the slowing decomposition till the four levels is performed. After this the gradient of the cD_4 would be calculated. After this calculate the zero crossings in the gradcD_4 space and there should be at least 3 zero crossings.

C. DETECTION OF DISEASE

i. *LEFT BUNDLE BRANCH BLOCK (LBBB)*

Left Bundle Branch block is the type of abnormality in the heart which causes delay in the activation of the left ventricle. In the normal case, both ventricles right and left should be expand and contract at the same time. But because of the left bundle branch block the right ventricle contract earlier then the left ventricle.

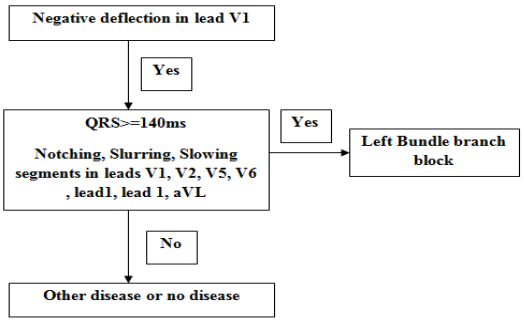

Fig.5: LBBB detection

To detect the LBBB problem, if there is notch present in the lead V1 is detected and deflection of V1 is negative and QRS has larger width then the normal like QRS>160ms or notching detected in V1, V2, V5, V6, lead1 then the patient would have left bundle branch block problem.

ii. *LEFT ANTERIOR FASCICULAR BLOCK (LAFB)*

Left ventricle has three type of muscle fibers are known as left anterior muscle fiber, left posterior muscle fiber and septal muscle fiber. In general cases, the posterior and the inferior posterior walls of the left ventricle get supply from the posterior muscle fiber. Anterior fiber give supply to the upper and anterior parts of left ventricle and the septal muscle fiber give supply to the septal wall.

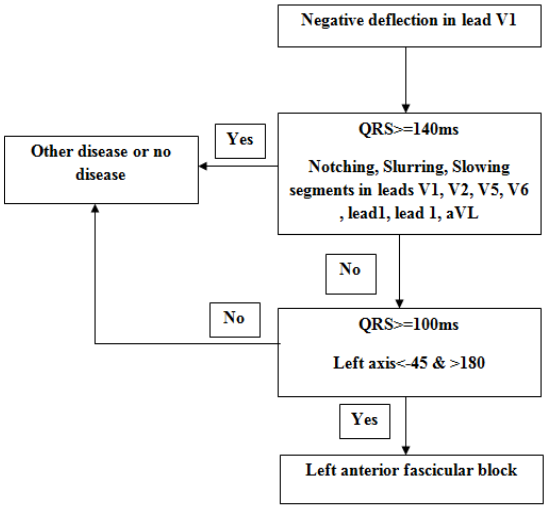

Fig.6: LAFB detection

Sometimes, posterior part of the ventricle gets supply earlier than the others. Due to this, there would be delay in the depolarization of anterior and upper parts of the left ventricle and this is known as LAFB. Because of this delay QRS axis

get widened and shift towards the left axis. If lead V1has negative deflection and patient have not LBBB disease detected then maybe there is LAFB so to detect it width of the QRS is not wide like it is around greater than 100ms and left axis have deviation -45 or -180. Same in case of if V1 have positive deflection then also patient may have LAFB problem.

iii. *RIGHT BUNDLE BRANCH BLOCK*

Generally, right ventricle activate by the impulses in the right ventricle and right bundle branch and left ventricle activate by the impulses in the left bundle branch. But in case of the RBBB, the right ventricle does not activate by the impulses in the right bundle branch but the left ventricle activated by the impulse in the left ventricle branch therefore the impulse would move through left ventricles myocardium and it activate the right ventricle. However the conduction of the right ventricles should be through the purkinje fibers but because of the myocardium membrane it would take the more time and that result in the RBBB. Because of this the duration of QRS will be wider than the normal QRS. To detect the RBBB we would observe to lead V1. If lead V1 have positive deflection and its QRS is wider than the normal then and it have not any left axis like -45 or -180 then the person will have RBBB problem If the lead v1 have positive deflection and QRS is also wider with -45 and -180 deviation then that patient would have the RBBB and LAFB both diseases.

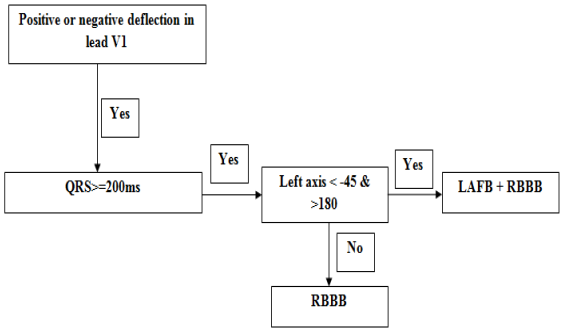

Fig.7: RBBB detection

iv. *TO CALCULATE PERCENTAGE OF HEART DAMAGE*

To check the percentage of heart damage, we have used the QRS scoring sheet. If patient have LBBB, RBBB, LAFB and LVH etc then by observing the abnormal signals the percentage of heart damage can be detected. As shown in the fig, there is a box for particular lead which is different for every type of disease and that is divided into two by spotted lines and then according to the criteria satisfied the corresponding score will be allotted. Only one score will be a lot from one box.

aVF	Q>=50ms	3
	Q>=40ms	2
	Q>=30ms	1
	R/Q<=1	2
	R/Q<=2	1

Fig.8: Headed for calculate percentage from one block

v. *REGION OF HEART DAMAGE*

There are 12 leads in the ECG and every lead introduces t he state of different parts of heart. The confounder in particular lead will inform about the region of heart damage.

III. RESULTS AND DISCUSSION

A. DETECTION OF DISEASE

If notching, slurring and slowing is present in any lead of the ECG that means patient have myocardial scar.

i. EXTRACTION OF NOTCHING

Notching is detected by using the SWT's 2nd and 3rd level decomposition

$$G(n-k) = a\,x(n-k) + b\,x(n-1-k) + c\,x(n-2-k) + d\,x(n-3-k) \quad (5.1)$$

a, b, c, d = filter coefficients

k = level of decomposition

If in both the levels the zero crossing is at the same point then notching is present at that point.

Table1- List of leads have notching

Patient No.	Notching Leads	Patient No.	Notching Leads	Patient No.	Notching Leads
1	L1, V1	7	V2	13	V2, V1
2	L3	8	aVF, L1	14	L1, L3, V1
3	L1, V1, V4	9	L2, aVF, V1	15	L1, V5
4	V6, aVR	10	L1	16	V5
5	V4	11	aVF, V1, V4, V5	17	L1, V5, L2, aVL, V3
6	V6, V5	12	aVL, V5	18	L2, V6, L1

ii. EXTRACTION OF SLURRING

Slurring can be detected by the 3rd level decomposition as shown in equation 5.3. If at the same level number of zero crossings more than 3 and less than 5 then slurring is detected at that point.

Table2 – List of leads have slurring

Patient No.	Notching Leads	Patient No.	Notching Leads	Patient No.	Notching Leads
1	V2, V4	7	V3, V5	13	V3, L1
2	V4, aVF	8	V6, aVL	14	-
3	L2, aVR, aVF	9	L3	15	V3
4	V4, V2, L2	10	V5, V4	16	V3, V4
5	L1, aVR, V2	11	V2	17	-
6	V2, aVF	12	L3, aVF	18	aVL, V1, V2, V5

iii. PERCENTAGE OF HEART DAMAGE

To check the heart damage percentage, we have been used QRS scoring sheet. After the detection of confounders in different leads QRS score can be calculate according to the QRS scoring sheet. Below is the table shows the calculation of heart damage in patient 15. Similarly by using QRS scoring sheet, we can measure the percentage of heart damage percentage in other patients.

By extracting the features like amplitude of Q wave, R wave and S wave and their time duration etc from the ECG signal are used to calculate the percentage of heart damage. After the detection of LAFB, LBBB and RBBB the heart damage percentage has been detected for 7 patients. Below is table of heart damage percentage for different patients.

Table 3 QRS score in different patients

Disease name	Patient number	Heart damage (percentage)
LAFB	6	7
LAFB	7	8
LAFB	8	6
LBBB	15	16
LBBB	16	13
LAFB	17	9
LBBB	18	15

IV. CONCLUSION AND FUTURE SCOPE

In this work, we have detected the diseases like Left bundle branch block, Right bundle branch block, Left anterior fascicular block, myocardial scar which lead to myocardial infarction by using electrocardiogram recordings. By using the QRS scoring sheet we have tried to quantify the heart damage. By observing the confounders in different 12 signals we have detected the region of the heart damage. Real time data has been used for the detection of disease, quantification of scar and region of heart damage. In 18 patient data, slurring in 35 signals and notching in 45 signals of different leads of different patient has been detected. In 7 patients we have find the percentage of heart damage. We have used SWT for the detection of features of ECG signal. Upcoming developments can be made as follows

- To design better feature extraction methodology with the intention to improve the results of classification of myocardial infarction aSnd other diseases.
- To use the other wavelets as mother wavelet or by altering the filter coefficients the results can be better.
- QRS score sheet can be improved for the precise quantification of scar.

Number of leads of electrocardiogram can be increase for better detection of the region of heart damage.

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