Plant Archives Vol. 19, Supplement 2, 2019 pp. 2131- 2133 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

A COMBINED APPROACH FOR THE CHARACTERIZATION OF CORONARY ARTERY DISEASE USING ELECTROCARDIOGRAM SIGNALS AND CARDIAC IMPEDANCE

Vineet Kumar
Department of Electronics and communication Engineering
Lovely Professional University, Phagwara- 144411, Punjab (India)
vineet.15921@lpu.co.in

Abstract

Coronary Artery Disease (CAD) is the core reason of various Cardio Vascular Disorders (CVD) such as High blood pressure, Cardiac arrest, Heart Attack (HA) and Stroke. In the presence of coronary artery disease blood and oxygen will not reach the heart muscle due to narrowed arteries path. Early detection and treatment of Coronary Artery Disease condition is essential to prevent from arrhythmogenic diseases. There are many noninvasive methods are there to analyse Cardio Vascular Disorders. However, an individual method may be imprecise on determining the patient's arrhythmogenic diseases. The precision for cardiovascular disease diagnosis can be improved by combining Electrocardiogram (ECG) and cardiac impedance. This paper presents a novel features detection of impedance cardiography parameter and Electrocardiogram R wave and the T wave based on ensemble empirical mode decomposition (EEMD). The mean cardiac index was significantly lower in group 1 by 2.19 L/min/m^2 compare to group 2 due to the presence of coronary artery disease. ECG signals are recorded parallels with cardiac impedance to obtain the features of cardiac impedance. Finally, the extracted features are used to calculate Cardiac Output to realize the characterization of the Coronary Artery Disease (CAD).

Keywords **:** Coronary Artery Disease , Cardio Vascular Disorders (CVD), cardiac impedance, ECG, Cardiac Output, Ensemble empirical mode decomposition (EEMD)

Introduction

Any injured portion of the blood vessels (coronary arteries) that are responsible to supply oxygenated blood in our heart is considered as Coronary artery disease. Once plaque has builds up, the inner cross sectional areas of coronary arteries narrows down and decreases the blood flow to your heart. In fact, the decreased blood flow may results discomfort in arms and shoulders. It may also cause shortness of breath, heart muscle pain (angina) and coronary artery disease. A large extent of deposition of plaque results full blockage can cause a heart attack. Because plaque deposition is a very slow process, it takes years to notice until it grow significantly.

ECG measurement is a routine part of any complete medical evaluation. Since it reflects the periodic electrical activity in term of amplitude, time duration and shape of the heart. Cordial tissues physiology and pathology change with respect to their bioelectrical impedance which can be investigate noninvasively [1-2]. Electrical impedance based noninvasive techniques like bioelectrical impedance analysis is used to calculate Cardiac Output to realize the characterization of the Coronary Artery Disease (CAD) [3].

Data Acquisition Process

A total of 20 subjects are taken in two groups. Group 1 comprised of 15 subjects having clinical evidence of coronary artery disease are taken and group 2 comprised of 15 normal subjects having more or less same height, weight, age matching with group 1 is taken in this work. All the signal are collected under natural breathing state.The cardiac impedance measurement process is conducted by placing four surface electrodes through which a low frequency alternating current having low amplitude is injected. The cardiac impedance is measured by dividing the voltage signal measured by the current signal applied assumes the human body as a cylindrical homogenous conductor [3].

Pre-Processing of Record based on EEMD

ECG signal and thoracic electrical bio impedance signal acquisition are contaminated with many kind of noise such as Power line high frequency interference, baseline wander, Electrode motion artifacts are present in these signals because of the internal tissue environment of the human body and external environment. For processing raw data it is essential to remove these artifacts present on it. Many techniques used to remove low and high frequency such as direct filtering and multiresolution analysis for this purpose. Electrode motion artifacts are present in ECG due to poor electrode contacts during data acquisition.. In this present work the removal of low frequency (baseline wander) and high frequency (power line interference) artifacts from raw ECG data has been done using Ensemble Empirical Mode Decomposition (EEMD) [4]. The Empirical Mode Decomposition method split the ECG signal into a group of intrinsic mode functions (IMFs).[5] These intrinsic mode functions behaves like a basis function and also adaptive in nature and directly derived from the signal values.

There are mainly four step in EMD algorithm and it can be summarized as follows:

1. Find the local maxima and minima of $x(t)$.
2. Interpolate these maxima by a cubic spline curve. Repeat it again with minima separately. This generates two envelopes $e_u(t)$ and $e_l(t)$ which are upper and lower respectively.
3. Finding the mean of the two envelopes:

$$m(t) = \frac{e_u(t) + e_l(t)}{2} \quad (1)$$

4. Find the detail signal d1(t) = d0(t) – m(t) and the standard deviation SD used in sifting process is given by

$$SD = \sum_{t=0}^{T} \frac{|d_{k-1}(t) - d_k(t)|^2}{d_{k-1}^2(t)} \quad (2)$$

5. Repeat the above four step until $d_k(t)$ behaves like the IMF (where k indicate kth iteration). c1(t) = dk(t). It gives the first IMF of $x(t)$. Repeat the above five steps for all residual $r_n(t) = x(t) - c_n(t)$ for getting all the IMFs. This whole procedure terminates when the residue $r_n(t)$ can be represented as very small monotonic function. The original signal can be constructed as

$$x(t) = \sum_{n=1}^{N} c_n(t) + r_N(t) \quad (3)$$

The QRS complex is the highest amplitude (normally 1.6 mv) and smallest duration wave (normally 90 ms) in the ECG signal. Since IMFs having lower order associated with high frequency and higher order IMFs representing the presence of low frequency. The algorithm is capturing the IMFs having lower order which correlate the presence of high frequency to detect the peak and amplitude of signal [6].

In this present work, we use first six IMFs is given by

$$f2c_6(t) = \sum_{i=1}^{6} c_i(t) \quad (4)$$

The three steps to mark the peak can be summarized as follows:

1) Apply adaptive threshold on absolute value of first six IMF and get an array y(t).
2) Put the amplitudes of y(t) larger than a threshold. This eliminates the noise.
3) When a non zero element of y(t) occurs, Find the position of the maximum within twice the duration of QRS complex .

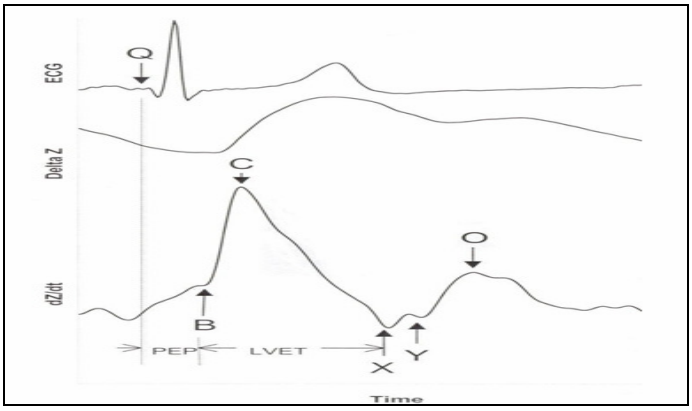

Fig. 1 : ECG , Impedance Waveform and their differential signal

The main feature points of cardiac impedance differential signal are shown in Figure 1 in the time-domain such as X representing closure aortic valve, C representing maximal slope, Y representing closure of pulmonic valve and point Q representing ventricular depolarization. The Impedance Waveform is used to calculate hemodynamic parameters, such as left ventricular ejection time (LVET), cardiac output, stroke volume, velocity index, Pre Ejection Period (PEP).

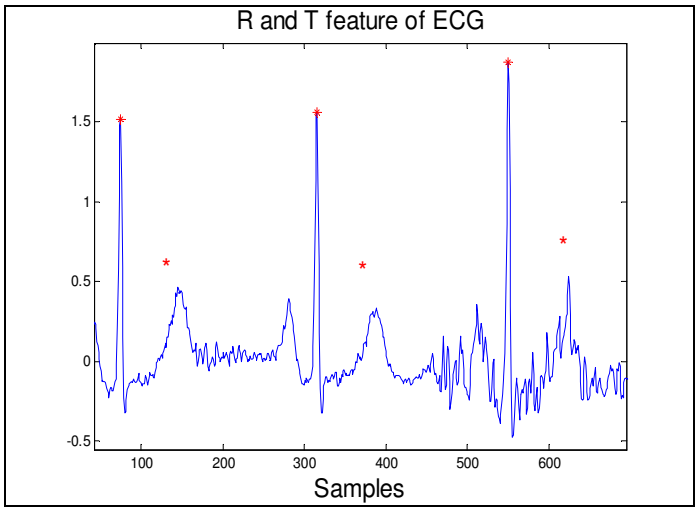

Fig. 2 : ECG R wave and the end point of T wave

ICG signal is used to mark point B, C wave and point X where as the ECG signal is used to mark R wave and the end point of T wave in Figure 2. The position of the QRS complex in the ECG signal is used to calculate the Heart Rate.

Data analysis of Cardiac Output

During one heartbeat, the volume of blood pumped by the left ventricle is given by Stroke Volume which can be measured by using the 1st derivative with respect to time of the cardiac impedance $\left(\left.\frac{dz}{dt}\right|_{max}\right)$ [7].

$$SV = K \times LVET \times \left.\frac{dz}{dt}\right|_{max} \quad (5)$$

Where SV refers to Stroke Volume [8], K depends on blood resistivity and distance between the electrodes during measurement and left ventricular ejection time (LVET) duration from the opening to the closing of the aortic valve. During one minute, the volume of blood pumped by the left ventricle is given by Cardiac Output (CO) which can be measured as the product of heart rate (HR)[9] and stroke volume

$$CO = SV \times HR \quad (6)$$

Table 1 : Mean value of impedance cardiography parameter

Parameter	Mean value In group 1	Mean value In group 2
Cardiac Index	2.01 L/min/m^2	4.2 L/min/m^2
Stroke Index	28 mL/beat/m^2	55 mL/beat/m^2
Velocity Index	37 /1000 / s	61 /1000 / s
Systolic Time Ratio	0.38	0.45

Stroke Volume and Cardiac Output are the derivation of the parameters to analysis their standard deviations [10]. The standard range of SV is 65 – 80 ml, and the reference range of CO is 4 -6.0L / min. Table 1 shows that the calculated Mean value of impedance cardiography parameter for Group 1 consisted of 15 subjects who had clinical evidence of coronary artery disease are taken and group 2 consisted of 15 normal subjects. Table 1 also shows that mean value of impedance cardiography parameter was significantly lower in

group 1 compare to group 2. Coronary artery disease has clearly been associated with low mean value of impedance cardiography parameter.

Conclusion

This paper presents a new approach to detection the Coronary Artery Disease using simultaneous data acquisition and processing of ECG signal and cardiac impedance signal. This paper also presents that patients have lower levels of cardiac output having high probability of coronary artery disease that can provide a dominant complementary reference for clinical medical diagnosis.

References

[1] Bera, T.K. and Nagaraju, J. (2011). Electrical impedance spectroscopic study of broiler chicken tissues suitable for the development of practical phantoms in multi-frequency EIT," Journal of Electrical Bioimpedance, 2: 48–63.

[2] Ahn, S.; Jun, S.C.; Seo, J.K.; Lee, J.; Woo, E.J. and Holder, D. (2010). "Frequency-difference electrical impedance tomography" Journal of Physics.

[3] Malmivuo, J. and Plonsey, R. (1995). *Bioelectromagnetism: Principles and Applications of Bioelectric and Biomagnetic Fields*, Oxford University Press, New York, NY, USA.

[4] Gurpreet, S.; Gagandeep, K. and Vineet, K. (2014). ECG Denoising Using Adaptive selection of IMFs through EMD and EEMD," International Conference on Data Science & Engineering (ICDSE), 228 – 231.

[5] Zhaohua, Wu. and Norden, E.H. (2009). Ensemble Empirical Mode Decomposition: a Noise-Assisted Data Analysis Method, proc. Advance in Adaptive Data Analysis, 1-41.

[6] Md. Abdullah Arafat and Md. Kamrul Hasan, (2009). Automatic detection of ECG wave boundaries using empirical mode decomposition" Proceedings of IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP 2009), 461-464.

[7] Kubicek, W.G.; Kottke, F.J.; Ramos, M.U. (1974). The Minnesota impedance cardiograph theory and applications. Biomed Eng, 9: 410.

[8] De Maria, A.N. and Raisinghani, A. (2000). Comparative overview of cardiac output measurement methods: has impedance cardiography come of age, Congest Heart Fail, 6(2): 60–73.

[9] Elstad, M.; Walloe, L. (2015). Heart rate variability and stroke volume variability to detect central hypovolemia during spontaneous breathing and supported ventilation in young, healthy volunteers. Physiol Meas, 36(4): 671–681.

[10] Bracco, D.; Thiebaud,´ D.; Chiolero, R.L.; Landry, M.; Burck-hardt, P. and Schutz, Y. (1996). Segmental body composition assessed by bioelectrical impedance analysis and DEXA in humans, Journal of Applied Physiology, 81(6): 2580–2587.