Modeling Cardiac Status: Implications of Cardiovascular Disease

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Abstract: Cardiac status can be described through spectral diagnostics tests. An easy noninvasive way to get the cardiac status is to conduct ECG test or echocardiography test. However, ECG test may not get the cardiac status accurate enough and echocardiography test is too time consuming and complicate. In this study, we proposed an assessment model for figuring cardiac status by blood pressure pattern (BPP) analysis which can accurately provide the cardiac status via the measurement of upper left arm brachial artery blood pressure of the patient.

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Introduction

The incidence of heart disease is so high to affect people's life all over the world. Most people may not know that they have cardiac problem before it happens. Factors, such as lifestyle problems, high cholesterol, smoking and high blood pressure, have been shown to be associated with heart attacks and myocardial infarction. The others, such as age and diabetes, kill people in silence. All of these factors are likely to lead to atherosclerosis, promote stenosis of the blood vessels, and increase the burden on the heart **[1]**. Referred to the theory of cardiovascular pattern analysis, we understand that echocardiography help physicians to accurately assess arterial and cardiovascular conditions **[2]**, providing information on the interaction between the heart and blood vessels. Therefore, blood pressure patterns may also be able to provide evidence for heart disease. In other words, the amplitude and shape of the waveforms of the heart pulse may reflect the physiological information of the heart and blood vessels **[3]**.

So far, various methods and instruments of measuring the pulse of the heart are available. Pulse related blood pressure pattern (BPP) can be very simple without allergic and discomfort at all. This study intends to use the sphygmomanometer to measure brachial artery pulse BPP to assess heart disease. The advantage is that the detection operation is simple and easy to carry.

Heart pulse BPP is mainly caused by cardiac diastolic and contraction **[4]**. However, either atrial or ventricular myocardium doesn't contract when depolarizing but does it after. Blood pressure monitor can be used to measure the systolic and diastolic blood pressure of the brachial artery on the arm. Basically, the motion of the atrial contraction occurs at the end of P wave in electrocardiogram (EEG) pattern after atrial depolarization **[5]**. Ventricular contraction movement occurs in the ECG ventricular depolarization after R wave being produced when the ejection period occurs after QRS complex wave occurs. Ventricular diastolic behavior occurs if the T wave being produced **[6]**. When the blood in right ventricle flows into pulmonary artery, pulmonary artery blood starts to flow through the left atrium into the left ventricle after the completion of a PQRST wave to produce a heart pulse.

Therefore, ECG and BPP should directly be correlated **[7].** For a normal heart, when the two atria shrink, the two ventricles will relax; when the two ventricular contracts, the two atria will relax. A cardiac cycle refers to BPP generated by a complete heartbeat, which includes two atrial systole and diastole, and the subsequent systolic and diastolic of the two ventricles. In quiet time, the average time of a cardiac cycle will not exceed 1 second. Assuming an average heart rate of 75 beats per minute, a cardiac cycle is 800 milliseconds. In the first 100 milliseconds of the cardiac cycle, left and right atrial will contract, two ventricular will relax. The mitral and tricuspid valves between the atria and the ventricle are open and the semicircular flap leading to the aorta and pulmonary arteries are closed. Following the next 300 milliseconds, two atrial will relax but two ventricular will contract.

In a cardiac cycle, all the valves will be closed and the two ventricles remain equal to contract at first. And then, the two half-moon flap will open. In next 400 milliseconds, two atrium and two ventricles will be relax to be in diastolic state, all valves will be closed. Mitral and tricuspid valve will then open and the blood began to flow into the two ventricles. In a completing cardiac cycle, atrial systolic period is of 100 milliseconds, diastolic period is about 700 milliseconds. Ventricular systolic period is close to 300 milliseconds but diastolic period is about 500 milliseconds.

We focus on the valve switching time caused by atrial, ventricular and arterial blood pressure changes to establish proper parameters to assess heart disease, especially myocardial infarction and myocardial weakness **[8, 9]**.

Method

We calculate the correlation of time intervals in BPP between the previous unit time and current time as well as the current and next unit time to construct a heart disease assessment model. If the signal is not a smooth process, then the autocorrelation function becomes a function of two variables. Basically, the correlation of the BPP will constitute a special conversion relation. This study proposed a new clinical model of using BPP to predict cardiovascular related diseases.

However, the relationship among mitral valve, tricuspid valve and semilunar valve is based upon systolic and diastolic blood pressure, with the blood supply time as a clinical basis. In the ventricle, when it lasts for a period of contraction the tricuspid and mitral valves are kept closed due to insufficient pressure to rush the flap to the pulmonary or aorta. When the diastolic atrium provides additional pressure, the pressure begins to shrink the ventricle, the valve must also be closed to prevent blood flowing back from the ventricle to the atrium, and the ventricle volume remains constant at this time.

From ECG patter analysis, the characteristics of the depolarized wave affect the measurements of BPP **[10]**. In a measurement of BPP, when the cuff is placed on the upper left arm to measure blood pressure synchronously, the signal is only from the arterial pressure. Our findings demonstrated that the information BPP correlations provide sufficient information to reflect the special relationship between cardiac pressure and time. In this study, Henan Provincial People's Hospital was set as a research base, through the approval of local IRB clinical trial, 50 volunteers with ECG test results were participated into the program to learn if the BPP clinical analysis can match the ECG diagnosis judgement into the assessment model.

In Table 1, the BPP and ECG totally eight parameters for the subjects are listed. The main purpose of this study is to verify the causal relationship between brachial artery pulse BPP and heart disease judged by ECG. to establish the assessment model for causal relationship of the parameters. In **Figure 1**, the variables are defined to correspond into the life time of the waves that cardiac valves created for the blood flow.

Table 1: Correlation Matrix for BPP variables

		QT	ICT	IRT	CJT	INF	DT	ASP	PT
Pearson Correlation	QT	1.000	.158	.229	.229	.112	.730	.332	.729
	ICT	.158	1.000	.017	.017	-.111	.363	.263	.365
	IRT	.229	.017	1.000	1.000	-.381	.335	-.603	.361
	CJT	.229	.017	1.000	1.000	-.381	.335	-.603	.361
	INF	.112	-.111	-.381	-.381	1.000	.173	.034	.149
	DT	.730	.363	.335	.335	.173	1.000	.401	.997
	ASP	.332	.263	-.603	-.603	.034	.401	1.000	.387
	PT	.729	.365	.361	.361	.149	.997	.387	1.000
Sig. (1-tailed)	QT	.	.107	.035	.035	.190	.000	.004	.000
	ICT	.107	.	.448	.448	.190	.002	.018	.002
	IRT	.035	.448	.	.000	.001	.003	.000	.002
	CJT	.035	.448	.000	.	.001	.003	.000	.002
	INF	.190	.190	.001	.001	.	.086	.393	.119
	DT	.000	.002	.003	.003	.086	.	.001	.000
	ASP	.004	.018	.000	.000	.393	.001	.	.001
	PT	.000	.002	.002	.002	.119	.000	.001	.
N	QT	64	64	64	64	64	64	64	64
	ICT	64	64	64	64	64	64	64	64
	IRT	64	64	64	64	64	64	64	64
	CJT	64	64	64	64	64	64	64	64
	INF	64	64	64	64	64	64	64	64
	DT	64	64	64	64	64	64	64	64
	ASP	64	64	64	64	64	64	64	64
	PT	64	64	64	64	64	64	64	64

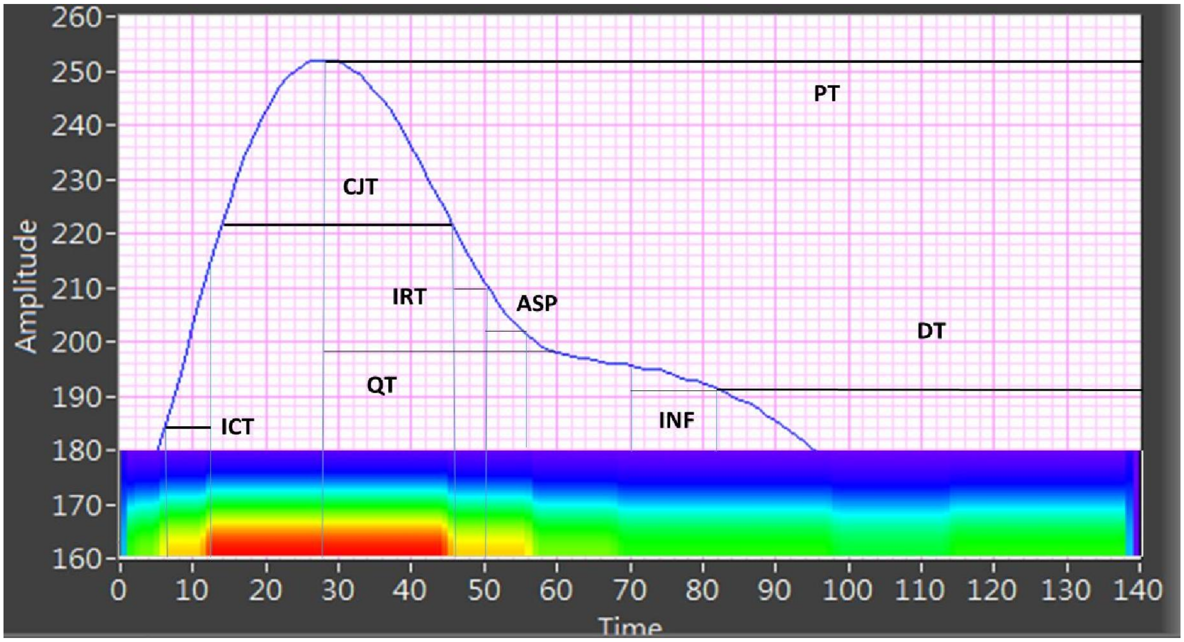

Figure 1. A cardiac cycle with the definition of the variables, each grid presents 5.6 m second

Table 2: Assessment Model for the predictor PT in BPP and the dependent variable of QT in ECG

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
C	0.613	.376	.370	29.7964

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
C	(Constant)	262.328	15.004		17.484	.000
	PT	.153	.018	.613	8.388	.000

Results

After analysis, we realized that the correlation coefficient of the subjects. The disease states were judged from ECG by professionals. In **Table 2**, it shows the model that we proposed to describe the disease state via ECG judgements for the subjects by professionals and the cardiac status PT measured from BPP. The R value in Table 2 is the correlation coefficient. Meanwhile, the beta value means the accurate rate that we can get QT value from PT. The model provide an equation to assess the QT by equation of QT = 0.018PT+15. The accuracy rate is 60% (0.613) from PT to assess QT. Since DT being as the diastolic time for the left ventricular, which is highly correlated with QT at correlation coefficient 0.73, we can conclude the cardiac status of left ventricular should be revealed by the model presentation of DT value.

Discussions

For preoperative myocardial infarction patients, QT is usually not in the normal range. BPP parameters are correlated with QT as the dependent reference to explore the impact of the weight of the parameters that is revealed in this study. The model that we proposed can determine the disease state through BPP parameters. When the heart cycle contains a factor that affects the heart contraction caused by heart disease, the BPP can be revealed. ECG interpretation of whether the heart is in the disease state or not can be referred to the BPP parameters DT.

Conclusions

By using of BPP model to identify cardiac disorder is a new technology which can be quickly applied to the general population for health examination. ECG is based on myocardial signal transmission of depolarization and polarization, however, BPP is based on brachial artery pulse signals characterized by the closure and open states of the valves. Heart function, especially disease states associated with myocardium, can be recognized through the BPP parameters as health concern reference. For health care workers, the new technique of BPP evaluation can quickly and accurately determine and the risks of cardiovascular disease, at the same time, give the most appropriate alarm and care. At present, many studies have confirmed that early arterial elastic dysfunction can be found in BPP analysis. Although using of brachial artery BPP as indicators for the assessment of heart is still in doubts, the early heart and vascular disease related to the relevant parameters of BPP at large-scale population and clinic research has been on the way. Measurement of brachial artery BPP is simple, invasive and valued for the assessment of cardiac disorder at first screen for patients in clinic.

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