EFFECT OF MENTAL STRESS ON RATE PRESSURE PRODUCT IN PATIENTS HAVING CORONARY ARTERY DISEASE AND IN AGE MATCHED NORMAL INDIVIDUALS.

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Abstract

Rate Pressure Product, a product of Heart Rate and Systolic Blood Pressure, is a good index of Myocardial Oxygen Consumption. Increased myocardial oxygen consumption is the good indicator of increased myocardial oxygen demand. The objective of study is to find out the effect of mental stress on heart rate, blood pressure and rate pressure product in coronary artery disease patients and in their age-matched normal counterparts. After necessary instructions, blood pressure and heart rate were recorded before and immediately after standardized mental stress (mental calculation for a minute) and rate pressure product was calculated among the volunteers (n=150, 75 coronary artery disease patients and 75 control, age 40-80 years) and then analyzed. The result of the study showed mental stress induced rise in rate pressure product in both the groups (Coronary artery disease: 17.77% and control: 9.88% from the baseline). Nevertheless, mental stress induced increase in rate pressure product in patients exhibited higher than that of their aged-matched normal counterparts, indicating increased oxygen demand in the former group. From this we conclude that the measurement of rate pressure product (casual and mental stress induced) may help the clinicians to predict/screen coronary artery disease, especially the silent ones, and can prevent sudden anginal pain in them.

Keyword: Blood Pressure, Coronary artery disease, Heart Rate, Mental stress, Rate Pressure Product.

Introduction

CAD (Coronary Artery Disease) is known to be one of the major causes of morbidity and mortality after the fifth decade of life which may be due to sedentary life style and rapid urbanization with changes in food habits (Rajeswari et al. 2012). Patients suffering from CAD are generally advised to avoid stress (physical/mental), which is body's reaction to any change that requires an adjustment or response. The body reacts to these changes with physical, mental or emotional response. These stresses can precipitate angina and myocardial ischemia (MI) (Schoder et al. 2000).

CAD is a disease where there is an imbalance between myocardial oxygen supply and demand. An adequate supply of oxygen to the myocardium depends on the oxygen level in inspired air, pulmonary function, hemoglobin concentration and coronary blood flow (Selwyn et al. 2005). The major determinants of myocardial oxygen demand are heart rate, myocardial contractility and wall tension, intra ventricular volume and pressure (Barrett et al. 2012, Libby et al. 2007).

Myocardial oxygen consumption (MVO_2) is a good indicator of increase myocardial oxygen demand (Rajeswari et al. 2012). Previous study shows close correlation with MVO_2 and RPP (Rate Pressure Product) value and concluded that RPP could be regarded as a measure of myocardial work of the heart (Jern et al. 1991) . RPP is the product of HR(Heart Rate) and Systolic Blood Pressure (SBP) (De Meersman et al 1998). It is a good index of MVO_2 in patients with ischemic heart disease (Zargar et al. 2002).

The mechanisms of mental stress-induced alterations in cardiac function are not well understood but it may be due to involvement of sympathetic activation, leading to an increase in heart rate (HR), blood pressure (BP) and myocardial contractility; with corresponding increase in myocardial oxygen demand (Yeung et al. 1991). The changing oxygen needs of heart with exercise and stress affect coronary vascular resistance. Cardiac work increases in individuals due to sympathetic stimulation caused by mental stress. Inability to supply oxygen to the myocardium when the demand is high appears to be related to several cardiovascular events including transient myocardial ischemia, acute myocardial infarction and sudden death (White et al. 1999). In a healthy heart, this supply of oxygen is more than the oxygen demand of the heart. But, in ischemic heart, a reversal of this relationship occurs, which means that the oxygen supply cannot meet the oxygen demand for a certain workload (Schoder et al. 2000). Patients having coronary artery disease exhibit an attenuated blood flow in response to mental stress (Schoder et al. 2000) which may contribute to mental stress-induced ischemic episodes in their daily life.

Mental stress that causes sympathetic stimulation is liable to increase HR, SBP and thus increases RPP (Watson et al.2006). In this context, it is justified to see how much alteration occur in RPP due to mental stress in patients with CAD and in normal individuals. Present study was undertaken to compare the alteration in mental stress induced RPP in patients with CAD and in normal individuals.

Materials and Methods:

This was a comparative descriptive study conducted in Shahid Gangalal National Heart Institute for over 1 year. The study population comprises of 75 patients with documented CAD and 75 healthy individuals with age more than 40 years. All patients had CAD, and none had undergone coronary artery bypass surgery. Those patients who had done bypass surgery were excluded. All normal healthy individuals having no CAD, chest symptom and not under any medication related to cardiac problem.

An informed consent was obtained from all volunteers. A detail clinical history of all the volunteers was taken. An electrocardiogram (ECG) was done in all volunteers. Coronary artery disease was confirmed by cardiac markers (CPKMB and troponin I) along with ECG and history.

Measurement of BP and HR

For every volunteer casual blood pressure and heart rate were recorded before the experimental procedure. Blood pressure was taken with the help of sphygmomanometer (Mercurial) and Littman Cardiosonic Stethoscope keeping the individual in sitting posture with a back rest after allowing him/her to take rest at least for 5 minutes. (Garg et al. 2002) Heart rate was measured using Littman Cardiosonic Stethoscope in mitral area for 1 min immediately after BP.

Intervention

The CAD patients were requested to perform mental arithmetic calculation for a minute with serial subtractions of 7 from 100 as quickly as possible. A metronome at a rate of approximately 90 beats/min was kept, which acted as an additive stressor component. Since none of the subjects were able to perform calculations at this high rate for more than a brief period of time, the subjects were repeatedly asked to increase the speed by short comments such as 'Try to go a little faster!', 'Follow the metronome!' etc. The number of correct responses was recorded, but wrong answers were immediately corrected. Throughout the test, the experimenter vigorously encouraged the subjects to perform at his/her maximum speed, but maintained an emotionally neutral attitude to prevent the subjects from a feeling of being harassed. (Jern et al. 1991) Blood pressure and heart rate were recorded immediately after that and rate-pressure product was calculated by multiplying heart rate and systolic blood pressure.

Age-matched controls were subjected to same mental stress through same experimental procedure for a minute as quickly as possible and their blood pressure and heart rate were also recorded immediately after that and rate-pressure product was calculated similarly.

Statistical Analysis

All the data were collected and analyzed statistically by using students'-test to find out significant variation between two study groups. The statistical analysis was performed by SPSS version 20.

Results

The study was carried out among 75 patients with documented CAD and 75 healthy individuals with age more than 40 yrs.ECG of all patients showed ST-elevation in different leads, CPKMB were found to have more than 35UL (mean 150UL) and all blood samples were troponin-I positive. All patients were receiving antiplatelet-drug and β-blockers and none underwent coronary artery bypass graft. Among them 5 had history of previous

MI, 10 had history of hypertension, 4 patients were taking Angiotensin-converting enzyme inhibitor and 15 received streptokinase. All patients continued their medication during procedure.

The resting rate pressure product, measured in beats per minute multiplied by mm of Hg, was similar in patients (9263.76±1520.95) and healthy volunteers (9042,8±1768.4). But during mental stress, the product increased significantly in patients (10873.0±1641.6) than in healthy individual (9929.8±1940.1) as shown in Table1 and 2

Table 1.Hemodynamic parameters of CAD patients at rest and during mental stress

Parameter	Patient		P value
	Rest	Mental stress	
HR(beat/min)	75.04±10.27	79.7±10.6	<0.05
SPB(mmHg)	123.9±15.91	136.8±13.57	<0.05
RPP	9263.76±1520.95	10873±1641.6	<0.05

Table 2.Hemodynamic parameters of normal healthy individual at rest and during mental stress

Parameter	Healthy Individual		P value
	Rest	Mental stress	
HR(beat/min)	76.3±9.0	80.0±9.54	<0.05
SPB(mmHg)	118.1±14.71	123.6±15.01	<0.05
RPP	9042.8±1768.4	9929.8±1940.1	<0.05

Here the heart rate increased only slightly in CAD patients (6.26% from the baseline) than in normal counterparts (4.97% from the baseline), but rise in SBP was higher in CAD patients (10.8% from baseline) than their normal counterparts (4.66% from baseline) which contribute to higher RPP in CAD patients (17.77% from baseline) than their normal counterparts (9.88% from baseline) as shown in Fig 1.

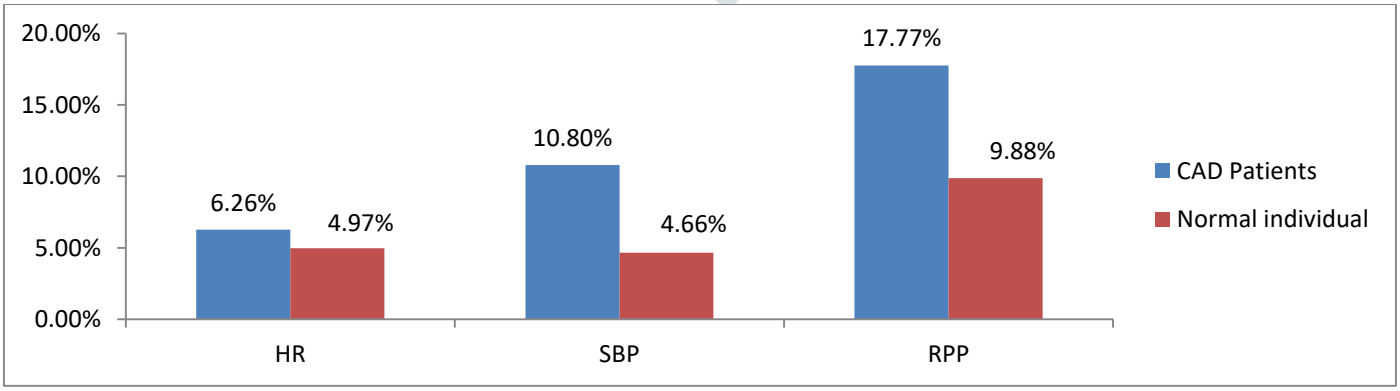

Fig 1: mental stress induced rise (%) in HR, SBP, and RPP among the CAD patients and normal individuals

Discussion

In the present work, all of the patients experienced anginal pain which was the reason of hospitalization. Formation of large amount of lactic acid in cardiac tissue may be the cause of anginal pain in myocardial ischemia. (Hall. 2011) Laboratory investigations revealed raised CPKMB and troponin I indicating myocardial ischemia (Champe et al. 2011) resulting from inefficient coronary flow. In patients of the present study, mean CPKMB was approx. 150 UL [i.e.,>35UL] and Troponin I values were (+) ve. In the entire patients ECG tracing showed ST segment elevation and in most of the cases T wave inversion was also present. ST segment elevation denoted more severe transmural ischemia in the present cases. Inverted T wave denoted repolarization abnormalities. (Selwyn et al. 2005) All these symptoms and laboratory findings confirmed that those patients had CAD.

We administered mental arithmetic as a stressor, as previous studies established it as a less potent stimulus than public speaking task in eliciting myocardial ischemia in CAD patients. (LaVeau et al. 1989; Ironson et al. 1992) Besides that, the patients were subjected to mental arithmetic (stressor) in hospital setting, so that if by chance anginal pain would occur as a result of myocardial ischemia the situation could be managed by using life supporting drugs and the specialist's care. Normal volunteers were also subjected to the same stressor.

Stress-be it physical or mental, increases work of heart and O_2 demand increases, raising RPP-the index of MVO_2. RPP, the product of HR and SBP appeared to correlate better with MVO_2 than MBF. MBF increased 71% while MVO_2 increased 81% when the normotensive men with angina pectoris were subjected to symptom tolerated maximal exercise. (Gobel et al. 1978) So RPP was established as a better index of MVO_2 than MBF.

During mental stress quick increase of activity in heart muscle occurs leading to increase in HR and SBP which eventually leads to increase in RPP indicating increased O_2 demand in them. (Bairey et al. 1993) Mental stress induced increase O_2 demand is seen in both normal and CAD patients. Present study noted higher mental-stress-induced-RPP value in CAD patients (17.77% increases from baseline) than the same in their age-matched normal counterparts (9.88% increase from baseline), indicating increased O_2 demand in them. We know, in case of normal individuals MBF increases to meet the demand but MBF does not increase accordingly in CAD patients. Nevertheless, the demand of energy does not alter; it rather increases.

In present study, casual/baseline HR in CAD patients was found to be lesser than that of their normal counterparts. It may be due to the effect of β-blocker (metoprolol) which was administered in all CAD patients who took part in our study. Casual/baseline BP in CAD patients was higher than the same in their normal counterparts as those patients were already in stress leading to raised plasma catecholamine level. Schoder *et al* also found higher baseline titer of serum epinephrine and Nor epinephrine (Epi: 36pg/ml; NE: 289pg/ml) in CAD than in normal counterparts (Epi: 29pg/ml;NE: 258pg/ml). (Selwyn et al. 2005) Increase titer of catecholamine might be the cause of raised causal/baseline BP.

Mental Stress through mental arithmetic increase heart rate and SBP in both normal volunteers and CAD patients in the present study. It is due to release of catecholamine in response to stress through sympathetic stimulation. The catecholamine (epinephrine) resulted increase in rate and force of contraction of heart leading to increase heart rate and SBP. (Berne et al. 2004).

For increase in RPP there should be an increase in heart-rate, or SBP, or in both. In the present study, there is no significant change in HR between normal and CAD patients but there is significant rise in SBP in CAD than in normal counterpart.

Mental stress induced increase in HR and BP was not severe in normal individuals than in CAD patients. Stress caused increase in catecholamine that increase the HR mediated by β1 receptor. Mental stress cause moderate increase in cardiac work. When neither blood nor epinephrine titer increases slowly in human, BP rises. Hypertension stimulates carotid and aortic baroreceptor producing reflex bradycardia that overrides the direct cardio-accelerating effect of nor epinephrine. (Barrett et al. 2012) So, HR and BP increased only slightly.

A rapid upregulation of beta adrenoceptors occurs during myocardial ischemia. This upregulation occurs in spite of a massive release of nor epinephrine from cardiac adrenergic nerves during ischemia. Both nor epinephrine release and upregulation of cardiac beta adrenoceptors lead to an adrenergic overstimulation of ischemic myocardium. (Haeusler. 1990) β-blocker significantly reduced peak mental stress heart rate; but mental stress triggered blood pressure elevation were not affected. (Bairey et al. 1993) So heart rate increased only slightly in CAD patients than in normal counterparts, but rise in SBP was higher in CAD patients than their normal (about 8% high than normal).

Conclusion and Limitation:

The measurement of RPP (casual and mental stress induced) may help the clinicians to predict/screen CAD, especially the silent ones, and can prevent sudden anginal pain in them. The result of the present study indicated that if mental stress induced rise in RPP is more than ~10% than that of casual RPP; it is recommended that the individual should be advised to go for ECG and other tests for further evaluation of cardiac function to do the needful. This may also be useful in prediction/early detection of CAD in remote areas where advanced diagnostic facilities (like ECG, cardiac enzyme measurement) is not available unfortunately. Nevertheless, it would be too early to announce the cut-off point of RPP value as the study population of our study was not enough due to limited time and feasibility. An extensive study is needed to determine the cut-off value of mental stress induced RPP for prediction of CAD, which will be beneficial for the patients.

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Conflict of Interests:

The authors declare that there is no conflict of interests.

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List of Abbreviation:

BP: Blood Pressure.

CAD: Coronary Artery Disease.

ECG: Electro Cardio Gram.

HR: Heart Rate.

MI: Myocardial Ischemia.

MVO_2: Myocardial Oxygen Consumption.

RPP: Rate Pressure Product.

SBP: Systolic Blood Pressure

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