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Alterations in Heart Rate Responses and the Effect of Supine and Sitting Recovery Positions on Heart Rate Recovery and Rate Pressure Product Following Submaximal Exercise Test in Patients Undergoing Coronary Artery Bypass Graft Surgery

Abstract

Objectives: The aim of the study was to determine

a) Whether there is any change in heart rate responses following submaximal exercise test in patients undergoing CABG

b) Is there any effect of recovery position on heart rate recovery and myocardial oxygen consumption following submaximal exercise test in patients undergoing CABG surgery???

Background: The imbalance in the autonomic cardiovascular control has been shown to increase the risk for adverse cardiac events and sudden cardiac death, which has been observed following CABG. Thus, it is important to clinically assess the status of the autonomic nervous system which is a major determinant of cardiovascular health and prognosis.

Interventions: The patients were randomly assigned to the two groups: group A and group B. Two six minute walk tests were performed each on the day at 9 a.m. and 1 p.m.; before surgery and following CABG on fourth and seventh postoperative day and the dependent variables were measured.

Results: The Peak Heart Rate improved highly significantly from 93.65 + 8.78 per minute on day 0 to 128.24 + 11.94 per minute on day 7 ($p<0.0001$). The Chronotropic Response Index improved significantly ($p<0.0001$) from 0.24 + 0.07 to 0.53 + 0.15 from day 0 to day 7. The Six Minute Walk Distance also improved significantly from day 0 to day 7 ($p=0.000$) from 299.93 + 66.63 m to 380.65 + 109.68 m. The results showed that the HRR increased from 23.06 + 10.43 per minute at first minute to 29.00 + 12.19 per minute at fifth minute, while RPP reduced significantly ($p=0.000$) from 12005.31 + 2681.83 mmHg/min at first minute to 10232.19 + 1783.22 mmHg/min at fifth minute of recovery. The results show the moderately significant ($p=0.00$) correlation between the HRR and the peak heart rate, and the HRR, chronotropic response index.

Conclusion: The study concluded that there is improvement in the heart rate measures and functional capacity following CABG. The heart rate recovery was also found to vary with different recovery positions and was better in the supine lying position, when compared to sitting position.

Keywords: Autonomic nervous system; Chronotropic response index; Heart rate recovery Six Minute walk test; Revascularization

Research Article

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Abbreviations: NHF: Normalized High Frequency; NLF: Normalized Low Frequency; TMT: Treadmill Testing; PHR: Peak Heart Rate; CR: Chronotropic Reserve; CRI: Chronotropic Response Index; 6 MWD: Six Minute Walk Distance; HRR: Heart Rate Recovery; RPP: Rate Pressure Product; RSA: Respiratory Sinus Arrhythmia; HRV: Heart Rate Variability; BRS: Baroreflex Sensitivity; Posn: Position

Introduction

Profound derangement of the autonomic regulation of cardiac function has been reported after CABG [1]. Imbalance in the autonomic cardiovascular control has been shown to increase the risk for adverse cardiac events and sudden cardiac death, in patients with CAD [2-4] emphasizing need for clinical evaluation of ANS.

The autonomic cardiovascular function has been traditionally evaluated by bedside tests such as respiratory sinus arrhythmia (RSA) and Valsalva maneuver. In the past two decades, quantification of heart rate variability (HRV) and Baroreflex Sensitivity (BRS) has been used as an indicator of the autonomic

control of the sinus rate [5] which are potent independent predictors of cardiovascular prognosis [2]. Although, neither of these measures made into the routine clinical practice as they require special equipment or do not have an intuitive appeal to the practicing clinicians [6].

The heart rate response to dynamic exercise follows a well-defined pattern modulated by the balance between vagal and sympathetic activity [7]. These measures are more straightforward and easily obtained measurements than other indices of cardiac vagal tone, [7-9] and are significant powerful and independent predictors cardiovascular and all cause mortality. Though, there are certain issues that deserves further investigation due to great diversity of methods used to investigate heart rate recovery (HRR) including test characteristics (maximal vs submaximal); different recovery times; recovery position [7], variable criterion for abnormality and other unresolved issues relating to the effects of chronotropic incompetence and beta-blocker use [10,11]. Thus, the aim of this study was to determine whether

1) There is any change in heart rate responses in patients undergoing CABG and

2) There is any effect of recovery positions on heart rate recovery and myocardial oxygen consumption in patients undergoing CABG.

Methods

Institutional Review Board of Studies consent was taken. The principles in the Declaration of Helsinki were followed during the conduction of the study. All the patients were recruited from the inpatient department of physical therapy and cardiopulmonary rehabilitation Delhi Heart and Lung Superspeciality hospital, New Delhi. The informed consent was taken from the patients before their inclusion in the study. The inclusion criteria was, patients undergoing elective Off Pump CABG, subjects who have previously undergone TMT (within one month before surgery), age group 46-71 yrs, male subjects, patients in normal sinus rhythm. The patients were excluded if they had unstable cardiovascular status, acute systemic illness or fever, implanted pacemaker, any previous cardiac surgery, any signs of peripheral neuropathy, any neuromuscular, skeletal impairment that would prohibit exercise. The patients were withdrawn if, withdrawal of consent postoperatively, any concomitant cardiac surgery, use of IABP, any post operative myocardial infarction or pulmonary complications, prolonged ventilator dependence (> 24 hrs.) [2], or prolonged ICU stay (> 48 hrs.)

Main outcome measures

Peak heart rate,Chronotropic reserve, Chronotropic Response Index, Heart Rate Recovery, Rate Pressure Product, Six Minute Walk Distance.

Independent variables

a) Recovery Position – Supine lying and Sitting

b) Day- Preoperative (Day 0), Fourth (Day 4) and Seventh (Day 7) Postoperative Day

c) Order of recovery position- Order 1 and Order 2.

Study design

This study with the same subject design has a repeated (three period) cross over design. The study included pre-test and post test measure of the dependent variables on a day before surgery, fourth and seventh post-operative day.

Procedure

On the pre operative admission of patient to the hospital, after thorough clinical assessment for inclusion and exclusion criteria, the method of study was explained to the patient and they were required to sign an informed consent. The patients were then randomly assigned to the two groups: group A and group B. Two six minute walk tests were performed each on the day at 9 a.m. and 1 p.m.; before surgery and following CABG on fourth and seventh postoperative day and the dependent variables were measured with the telemetry apparatus (Sync Master 773s, Samsung), teleguard with SpO_2 probe and NIBP apparatus.

In Group A (Order 1) - After 6MWT's, the patients were subjected to the supine lying position in the morning and to the sitting position in afternoon. In Group B (Order 2) - After 6MWT's, the patients assumed sitting position in the morning and supine lying position in the afternoon. The patient assumed supine lying position on the bed, and sitting position refers to the 90° upright sitting position on a chair, with back of the patient supported.

Data analysis

The data was analyzed using the Statistical Package for Social Sciences (SPSS, version 15.0, Chicago, IL, U.S.A.). Multivariate analysis of variance (MANOVA) was used to analyze the effect of the independent variables and their interactions on the dependent variables. The univariate analysis of variance (UNIANOVA) was used to determine the effect of Day on the chronotropic variables and six minute walk distance. The HRR and RPP were analyzed using the repeated measures analysis of variance at each level of measurement. The post hoc comparisons were performed for each dependent variable using the Bonferroni corrections. The Pearson's coefficient of correlation was used to analyze the correlation between the dependent variables. Descriptive statistics are presented as mean + standard deviation. A critical alpha (α) probability (p) value of 0.05 or less was deemed significant and 95% confidence intervals were calculated for all the variables.

Results

A total of 43 patients participated in the study; of whom, 36 patients completed the study. The reasons for withdrawal include: withdrawal of consent following surgery (n=2), concomitant intraoperative valvular surgery (n=1), prolonged stay in the intensive care unit (>48 hrs) (n=2) and postoperative use of IABP (n=2). The demographic data of the patients included in the study is summarized in Table 1, which shows that the two groups were homogenous with respect to the baseline demographic characteristics. The multivariate analysis of variance (MANOVA) was used to analyze the effect of independent variables on dependent variables. The test of between subjects effect in MANOVA revealed that the chronotropic variables and six minute walk distance varied significantly with 'Day' as shown in Table 2.

After the significance of the independent variable 'Day' was established by the multivariate F tests of group differences, the post hoc tests were performed using univariate analysis of variance (UNIANOVA) to analyze the effect of day on chronotropic variables and six minute walk distance as shown in Table 3. The other two dependent variables; Heart Rate Recovery (HRR) and Rate Pressure Product (RPP) were measured at each minute till five minutes of recovery. The repeated measures ANOVA was used to analyze the variation of these two dependent variables at each individual level, as shown in Table 4.

The post hoc analysis of HRR revealed that HRR increased significantly till fourth minute of recovery though the improvement was insignificant (p=1.00) from fourth minute to fifth minute of recovery. The post hoc analysis of RPP showed that it reduced highly significantly (p=0.000) at all time points from first to fifth minute of recovery. The variation of HRR and RPP with time and day is summarized in Figure 1 & 2 respectively.

Figure 3 & 4 show the effect Position and Day on HRR and RPP respectively. The Pearson's analysis of correlation was used to analyze the correlation between the heart rate measures during and after the exercise, as shown in the Table 5. Figure 5 & 6 depict the regression equation and the R^2 values for the variables.

Table 1: Patients Demographic Data.

Characteristics	Group A	Group B	T test	
	Mean + S.D	Mean + S.D	T	P
Age	56.00 + 6.50	59.44 + 6.91	6.91	0.13
Height	164.50 + 6.30	163.83 + 5.91	0.33	0.75
Weight	64.61 + 5.99	64.89 + 6.13	-0.14	0.89
BMI	23.92 + 2.23	24.15 + 1.52	-0.37	0.71
No. of Grafts	2.94 + 0.42	2.89 + 0.47	0.38	0.71
EF	51.06 + 5.77	52.72 + 8.10	-0.71	0.48

Table 2: Effect of Independent Variables on Dependent Variables.

Variables	P Value						
	Order	Posn	Day	Order*Posn	Order*Day	Posn*Day	Order* Posn*Day
Peak HR	0.66	0.96	0.0001	0.42	0.03	0.90	0.40
CR	0.08	0.29	0.0001	0.40	0.07	0.50	0.40
CRI	0.09	0.42	0.0001	0.56	0.09	0.82	0.52
6MWD	0.65	0.96	0.0001	0.99	0.03	0.94	0.99

Peak HR: Peak Heart Rate; CR: Chronotropic Reserve; CRI: Chronotropic Response Index; 6MWD: Six Minute Walk Distance; Posn: Position

Table 3: Effect of Day on Chronotropic Variables and Six Minute Walk Distance.

Variable	Day 0	Day 4	Day 7	ANOVA		Post Hoc Significance		
	Mean + S.D.	Mean + S.D	Mean + S.D	F	P	0 to 4	0 to 7	4 to 7
Peak HR	93.65 + 8.78	117.71 + 11.00	128.24 + 11.94	211.71	0.0001	0.0001	0.0001	0.0001
CR	89.75 + 8.44	73.94 + 13.90	73.06 + 11.81	55.51	0.0001	0.0001	0.0001	0.62
CRI	0.24 + 0.07	0.40 + 0.12	0.53 + 0.15	119.46	0.0001	0.0001	0.0001	0.0001
6 MWD	299.93 + 66.63	313.40 + 112.42	380.65 + 109.68	16.78	0.0001	0.37	0.0001	0.0001

Day 0: Preoperative Measure

Day 4: Fourth Postoperative Day

Day 7: Seventh Postoperative Day

Table 4: HRR and RPP at Different Levels.

Variable	Recovery Time					ANOVA	
	1	2	3	4	5	F	P
	Mean + S.D	Mean + S.D	Mean + S.D	Mean + S.D	Mean + S.D		
HRR	23.06 + 10.43	27.50 + 11.23	28.37 + 11.79	28.87 + 12.05	29.00 + 12.19	52.89	0.0001
RPP	12005.31 + 2681.83	11053.33 + 2290.82	10658.34 + 1975.42	10381.09 + 1758.42	10232.19 + 1783.22	80.75	0.0001

HRR: Heart Rate Recovery; RPP: Rate Pressure Product

Recovery Time in Minutes

Table 5: Correlation of the Dependent Variables.

Variables	P.HR		CR		CRI		6MWD	
	r	P	R	P	r	P	r	P
HRR 1	0.48	0.0001	0.01	0.90	0.61	0.0001	0.19	0.01
HRR 2	0.59	0.0001	-0.01	0.86	0.74	0.0001	0.29	0.0001
HRR 3	0.62	0.0001	-0.02	0.82	0.78	0.0001	0.32	0.0001
HRR 4	0.65	0.0001	-0.01	0.92	0.80	0.0001	0.37	0.0001
HRR 5	0.65	0.0001	-0.02	0.76	0.81	0.0001	0.37	0.0001

r- Pearson's Coefficient of Correlation

p≤ 0.05

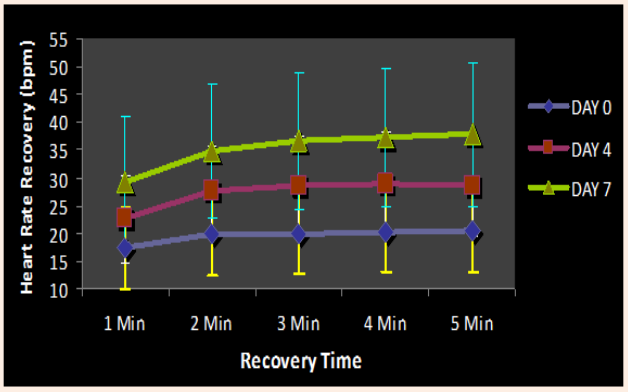

Figure 1: Variation of Heart Rate Recovery after Walk Test following CABG.

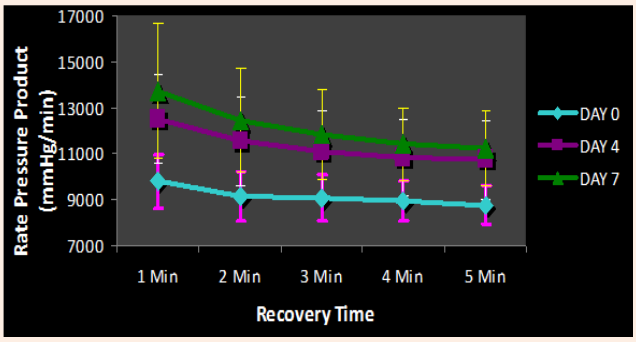

Figure 2: Variation of Rate Pressure product during recovery following CABG.

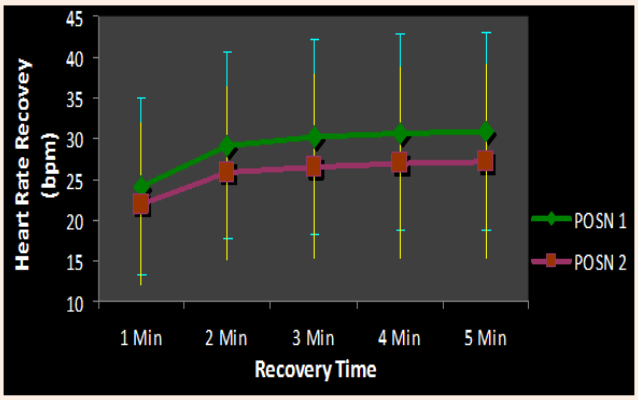

Figure 3: Variation of Heart Rate recovery with positions.

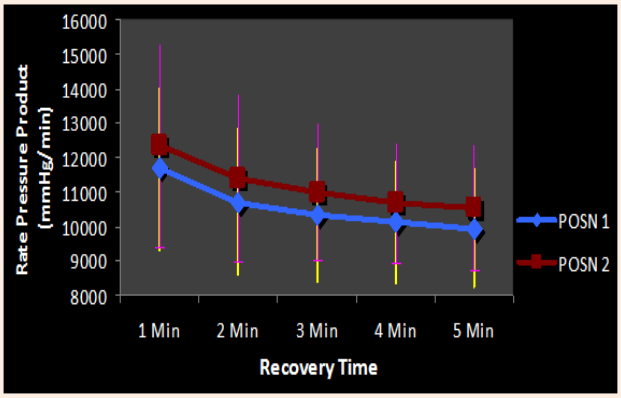

Figure 4: Variation of Rate Pressure Product with Positions.

Citation: Arora K, Ahmed F, Bangi NA (2015) Alterations in Heart Rate Responses and the Effect of Supine and Sitting Recovery Positions on Heart Rate Recovery and Rate Pressure Product Following Submaximal Exercise Test in Patients Undergoing Coronary Artery Bypass Graft Surgery. J Cardiol Curr Res 2(6): 00085. DOI: 10.15406/jccr.2015.02.00085

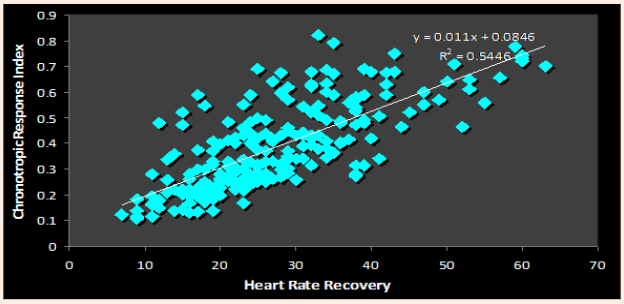

Figure 5: Correlation of Heart Rate recovery and Chronotropic response Index.

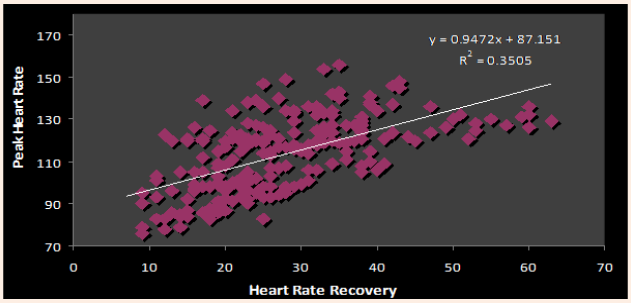

Figure 6: Correlation of Heart Rate recovery and Peak Heart Rate.

Discussion

The status of the autonomic nervous system, although often ignored by the clinicians, is a major determinant of the cardiovascular health and prognosis. The complex interaction of the ANS and the cardiovascular system (CVS) during exercise can be easily assessed by the heart rate response to exercise (reserve) and the heart rate recovery (HRR) after exercise. There is abundant literature evidence supporting the view that, there is impairment of the CV autonomic function following CABG. Thus, this randomized trial evaluated the changes in the HR responses to exercise and HRR after exercise in the patients undergoing CABG. Secondly, the study also explored the effect of the different recovery positions, i.e., supine and sitting on the HRR and the myocardial oxygen consumption. This is perhaps the first study using the Six Minute Walk Test to evaluate the changes in the HR responses to exercise and HRR after exercise in the patients undergoing CABG and the effect of recovery position of HRR and RPP.

The chronotropic responses to exercise including Peak Heart Rate and Chronotropic Response Index (CRI) showed significant changes following CABG. The peak heart rate showed a highly significant ($p<0.001$) increase from preoperative to fourth and seventh postoperative day and from fourth to seventh postoperative day. This significant increase in maximum heart rate during exercise following CABG may be due to the previous and concomitant use of the ß- blockers by all the patients in the study. The ß- blockers lower the heart rate and help to restore normal ß-receptor responsiveness, improving peak exercise heart rate,i.e., heart rate response during exercise [12]. Also, CHD patients have lower systolic volume than the normal individuals which would have been exaggerated following surgery, which would have led to increase in peak heart rate achieved after surgery [13]. Peak heart rate rise may also be due to more energy demand as the patients have walked a longer mean distance following and the altered postoperative hemodynamics of these patients.

The Chronotropic Response Index also improved with days at all intervals. The previous studies suggest no association between diabetes mellitus and chronotropic response to exercise, which was similarly found in this study as both diabetics and non diabetic patients improved following surgery [14]. Though, the proportion of heart rate reserve used during exercise has improved following surgery, this may not be an appropriate response to exercise. But, since there is no current evidence defining the normal cut off values for exercise response following cardiac surgery, the exercise response obtained during this study can not be classified as chronotropic incompetence. Although, the chronotropic response of < 62% in the patients taking ß- blockers has been classified as the chronotropic incompetence (CI) [15], but these results may not be extrapolated to the present study. The CI has been found to be more common in patients taking ß-blockers [16] which may have led to the results of this study.

Though, the ß- blockers have been found to have minimal impact on the prognostic power of CI [15,17]. The lower HR reserve percent used during the exercise has been found to be associated with higher risk for incident CAD and mortality, which is independent of the age, functional capacity, HR at rest and exercise protocol [14,18]. The autonomic imbalance that governs the HR response during or after exercise is disturbed following CABG, which may have led to the inability to use most of the heart rate reserve during exercise [7]. Although, it has been found that the impaired HR response with exercise is a protective reflex that allows perfusion to myocardium in response to cardiac ischemia by prolonging diastole [14]. The attenuated HRR has been found to be an independent and strong predictor of mortality even in the absence of the cool down period, Diabetes mellitus, use of antihypertensive medications, previous myocardial revascularization, exercise capacity, chronotropic response, ß-blockers, ACE inhibitors and calcium channel blockers [14,18,19].

The present study evaluated the variation of HRR-

(1) with increasing recovery time,

(2) following CABG and

(3) with different recovery positions.

The HRR increased significantly with increasing recovery time except for insignificant increase from 4th to 5th minute during recovery. This finding can be attributed to the normal interplay of the ANS after exercise [3,20,21]. The preoperative HRR in the patients in this study was found to be abnormal at 2nd minute of recovery, which is in accordance with the finding of the study by Pedro Paulo S and Jurij- Matija Kalisnik [1,2,22], which suggests that the cardiac vagal modulation is reduced in patients with CAD or previous myocardial infarction. But, the recovery at 1st minute which has also been supported as a measure to predict CV mortality was found normal preoperatively. The similar findings have been reported in a study by Ricrado, which shows that only

17% of their patient population showed abnormal HRR responses despite of the status that may have influenced the autonomic activity [10]. It may thus be inferred that the HRR at 2nd minute is more sensitive to detect the impaired autonomic modulation in the CAD patients, which was similarly found in the study by Katerina Shetler [23]. Heart rate recovery, in this study, showed a significant improvement at all time points on all days. This finding is contradictory to the available literature which suggests that there is depression of the cardiac autonomic modulation following CABG [7,12,24] It has been found that the induction of anesthesia during surgery causes a decrease in HRV. Also, CABG itself causes reduction of the HRV indices. Also, the systemic inflammation that follows CABG has been found to decrease the autonomic modulation of heart.

Though, the results of the present study can be supported in the light of the following studies. A study by Matija et al. [22], reported an increase in the HF and nHF component of HRV spectral analysis on the fourth and seventh postoperative day as compared to the preoperative values [22]. The LF/HF ratio showed an increase in sympathetic discharge from preoperative to postoperative state. A study by Bauernschmitt also suggests that HRV parameters at the beginning of the ICU-course were comparable to the preoperative values and to values of healthy volunteers in their study. Thus, they concluded that the surgery (CABG) per se does not seem to have major impact on this parameter [25].

Since, it has been found that recovery from 30s-2minutes is vagally mediated and later recovery depends on sympathetic modulation [17], the improvement in HRR at 2nd minute in this study, may suggest that the revascularization (CABG) may also improve HRR postoperatively. The improvement in the HRR in this study suggests that the ß- blockers do not affect HRR which may provide a step further in solving the prevailing conflicting evidence regarding the effect of ß- blockers on HRR. Also, the clinical administration of the cardiovascular drugs have been found to have no significant impact on the prognostic value of Heart Rate Recovery [19,23,26]. The improvement in HRR in the study may also be attributed to the exercise regime provided to the patients during their inpatient stay in the hospital. Although, this factor alone is less likely to cause any significant improvement. Thus, whether short term training provided during Phase I cardiac rehabilitation can positively effect the impaired autonomic modulation or not can not be certained at this moment due to lack of the available evidence and warrants further investigation into this matter. The increased respiratory rate during exercise may also have improved the HRR. The statistically significant increase in the respiratory rate has been found during ambulation [27] and a strong respiratory modulation has been observed in the cardiac vagal outflow in humans [28]. This interaction observed may be because the cell bodies of the efferent limb of parasympatheticfunction involving cardiacvagal motor neurons, reside in boththe dorsal motor nucleus of the vagus and the nucleus ambiguous, which are sensitive to both baroreceptor and the respiratory activity [29].

More recently, the mechanisms responsible for postexerciseHRR have been challenged, even contesting its prognostic value [13]. Thus, currently it seems that the HRR requires further investigation and refinement before the definitive criteria for its clinical use and interpretation can be adopted. The results of the study show a significant correlation among the chronotropic variables and Heart Rate Recovery which is in accordance to the available literature. These results underlie the assumption that, both the coefficients are dependent on the autonomic nervous system. The cardiac acceleration during exercise and deceleration after exercise is thought to involve an interplay between the two limbs of the autonomic nervous system, which points towards the possibility of the "accentuated antagonism" suggesting that the activity of one limb of the autonomic nervous system is directly related to the activity of the other limb [18]. Though, different physiologic mechanisms are responsible for these initial and final HR transients. The rapid initial HR transient is exclusively mediated by vagal inhibition. On the other hand, the physiological mechanisms involved in the postexercise transient are unclear. Though, the reduction in the adrenergic component seems to play a greater role in the subsequent HR decrease. Thus, it may be concluded that the information obtained from both the transients is complementary [7].

Although, the prognostic clinical usefulness of HRR presents strong epidemiologic evidence under different conditions and methods, the results from the previous studies on the methods of quantization the initial and final HR transients suggest that HRR measurements may be unreliable in men and women with or without symptoms. Conversely, the results of the intraday and interday calculations of the chronotropic heart rate responses have been found to be highly reliable in a large and heterogeneous sample under a variety of clinical conditions. It is thus possible that the chronotropicHR responses may also provide a relevant, complementary prognostic indicator, based on its more objective dependence on cardiac vagal integrity, high reliability, and modest association with the final transient. Also, the higher discriminatory power of the initial transient compared with HRR has been supported by various studies [17].

Therefore, in contrast to initial transient, the widespread use of HRR measurements may present an additional challenge (i.e., low reliability), potentially compromising the clinical analysis and implications.

The Rate Pressure Product (RPP) or the double product which signifies the myocardial oxygen consumption was evaluated for its variation

a) During recovery

b) Following CABG

c) With different recovery positions.

The results showed a significant reduction in the RPP during recovery (over 5 minutes). This is supported by the available literature which suggests that there is arterial vasodilatation immediately following the exercise and decrease in HR during recovery due to sympathetic withdrawal and parasympathetic reactivation, which would have caused the reduction in RPP during recovery [20]. The RPP was found to increase significantly from preoperative to postoperative period, though the increase was insignificant from fourth to seventh postoperative day due to progressive myocardial recovery. The increase in RPP following

surgery may be attributed to the surgical stress due to acute injury to the myocardium during the surgery [3]. The increased metabolic demand of the acutely injured myocardium increases its oxygen requirement to perform the work of the myocardial contractility, thus justifying increased RPP following surgery.

The present study suggests that recovery in the supine position following the six minute walk test in the immediate phase following CABG is better than recovery in the sitting position. This is because of more HRR and lower RPP (myocardial oxygen consumption) in supine position when compared to the sitting recovery position. This may be because; there is transient decrease in the venous return immediately following exercise, which reduces coronary blood flow when the HR and the myocardial oxygen demands may still be high. Thus, when the patient assumes the supine position following exercise, the venous return is increased, which increases the stroke volume, thus reducing the need for HR to increase, to adequately augment the cardiac output to meet the increased metabolic requirements of the body. This is supported by the fact that the stroke volume and heart rate are inversely related to each other [30]. In contrast to the above situation, during recovery in the sitting position; the venous return is further reduced which requires the heart rate to increase proportionately, to enhance the cardiac output which in turn requires the increased myocardial contractility, thus increasing the myocardial oxygen consumption, i.e., RPP [20].

Also, in earlier research studies, the blood catecholamine levels have been found to be higher in the upright position than in the supine lying position [31,32]. These higher catecholamine levels correspond to the enhanced sympathetic activity in the sitting position than in supine position, thus favoring recovery in the supine position. The results also suggest that HRR varies with different recovery positions. This may help to reduce the current methodological variations prevailing to investigate the HRR after the exercise. The evidences thus suggest that the six minute walk test might be useful for evaluation of exercise tolerance in phase I and phase II of inpatient cardiac rehabilitation programs or to assess functional responses to selected interventions early after the acute event.

The six minute walk test in this study was well tolerated by all the patients with no need for pauses or interruptions due to symptoms except for two patients who stopped test at 4 minutes 10 seconds during the morning test on fourth postoperative day and another patient who also interrupted the test on the fourth postoperative day, during the afternoon test, at 5 minutes 21 seconds due fatigue. The significant improvement in the distance walked, from preoperative to postoperative period; during the six minute walk test has been found in the present study, which is in consistence with the results of the study by A. Hirschhorn et al. [33] The improvement would have been because of the exercises of the hospital based inpatient physiotherapy protocol administered similarly to all the patients of both the groups. Also, the drugs such as ß- blockers and ACE inhibitors have been found to improve exercise capacity [34]. Thus, there might be role of these drugs in improving the walk distance significantly. Thus, the increased six minute walk distance following surgery suggests that the surgery per se does not seem to affect the functional capacity of an individual following exercise.

Conclusion

The findings of the present study suggest that, the six minute walk test can be safely administered as early as first week following elective CABG. There is improvement in the HR responses to exercise and after exercise following CABG. The chronotropic variables may better represent underlying cardiac autonomic dysfunction than the Heart Rate Recovery. The heart rate recovery varies with the recovery position and has been found to be better in the supine position when compared to the sitting position. The normal exercise responses following surgery suggests that cardiac surgery (CABG) does not cause any exercise impairment. But this study had several limitations, including; Small sample size of the study, although the present study had the statistical power of > 85%, no females were included in the study, the present study included only low risk patients, only postoperatively stable patients were included and more definitive measures of the cardiac autonomic modulation, i.e., Heart Rate Variability and Baroreflex Sensitivity were not used to assess the changes in the autonomic nervous system in the early phase following CABG, although HRR shows significant correlation with these definitive measures.

Limitations of the Study

Small sample size of the study, although the present study had the statistical power of > 85%, No females were included in the study, the present study included only low risk patients, Only postoperatively stable patients were included, More definitive measures of the cardiac autonomic modulation, i.e., Heart Rate Variability and Baroreflex Sensitivity were not used to assess the changes in the autonomic nervous system in the early phase following CABG, although HRR shows significant correlation with these definitive measures

The findings of the present study may be concluded as follows:

The six minute walk test can be safely administered as early as fourth postoperative day following elective CABG, the improvement in the HR responses during and after exercise following surgery suggests that CABG may improve these autonomic measures early following the surgery, the improvement in the chronotropic variables and heart rate recovery in immediate post operative period also implies that these mortality predictors may be modified (improved) in the early phase (Phase I cardiac rehabilitation) following CABG, it may thus also be concluded that the adverse effects of CABG on the cardiac autonomic modulation are presently over-exaggerated. The chronotropic variables may better represent underlying cardiac autonomic dysfunction than the Heart Rate Recovery, the heart rate recovery varies with the recovery position and has been found to be better in the supine position when compared to the sitting position, the normal exercise responses (i.e., normally declining heart rate and RPP during recovery), following surgery suggests that cardiac surgery (CABG) per se does not cause any impairment in responses to the submaximal exercise.

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