Al-Azhar Med. J.(Cardiology) *Vol. 49(4), October, 2020,1845 - 1852*
DOI : 10.12816/amj.2020.120640
https://amj.journals.ekb.eg/article_120640.html

HEART RATE RECOVERY TIME AFTER EXCERCISE STRESS TEST IN DIABETIC PATIENTS WITH SUSPECTED CORONARY ARTERY DISEASE

By

Ahmed Zein Elabedin Mohammed , Mohammed Osama Fathy Kayed , and Mohammed Samy Abd El-Samee

Department of Cardiology, Faculty of Medicine, Al Azhar University

E-mail: ahmedzein2019zizo@gmail.com

ABSTRACT

Background: Improving recovery after exercise is vital for decreasing cardiac mortality by dominance of parasympathetic nervous system control in recovery time.

Objective: To determine the influence of coronary artery disease on heart rate recovery after exercise in patients with diabetes mellitus.

Patients and Methods: The ethical approval was obtained from the hospital ethical research committee, in cardiology department in Al-Hussein university hospital from March 2019 to November 2019 and each patient signed an informed consent. Fifty patients were included in this study divided in 4 groups, all with no evident history of ischemic heart disease. Detailed history, physical examination, resting ECG, trans thoracic echocardiography, and finally treadmill exercise stress test was done. In this study we assessed heart rate recovery in 1st, 2nd& 3rd minute and also basal heart rate included.

Results: Significant delay in heart rate recovery time was detected in diabetic patients with positive stress ECG test for myocardial included ischemia.

Conclusion: Delayed recovery and reduced heart rate recovery after treadmill exercise stress test is an available and important index for detecting and revealing the extent of ischemic burden.

Keywords: Treadmill exercise stress test, Transthoracic echocardiography, Heart rate recovery, Duke treadmill score.

INTRODUCTION

Despite considerable improvements in the identification and treatment of coronary artery disease (CAD), this condition remains highly morbid and is the most common cause of death in the Western world *(Murphy et al., 2013)*.

The latest American College of Cardiology (ACC)/American Heart Association (AHA) guidelines on exercise testing, diagnosis, and management of stable ischemic heart disease and ACC/AHA appropriate use criteria for cardiac radionuclide imaging recommend exercise stress electrocardiography (Ex ECG) as the initial diagnostic test in patients at intermediate pre-test risk who are able to exercise and have an interpretable resting electrocardiogram *(Fihn et al., 2012)*.

The diagnostic and prognostic value of exercise ECG testing can be enhanced by

incorporating in the assessment additional clinical data that exercise testing provides beyond the detection of ST-segment depression: exercise capacity, chronotropic and blood pressure response, heart rate recovery, calculation of the Duke Treadmill score, T-wave alternans *(Sharma et al., 2012).*

The diagnostic accuracy of exercise ECG can further be improved by analysis of the relation between ST-segment depression and heart rate changes during exercise and recovery *(Fletcher et al., 2013* and *Bourgue & Beller, 2015).*

Heart rate adjustment of ST-segment depression during exercise performed by calculating the ST-segment/heart rate (ST/HR) slope or the ST/HR index can improve the sensitivity with preservation of specificity, mainly from improved classification of patients with equivocal test responses related to up-sloping ST-segments *(Minkkinen et al., 2015).*

Despite these recommendations, the majority of patients still undergo stress imaging as the initial testing strategy. In the PROMISE (Prospective Multicenter Imaging Study for Evaluation of Chest Pain) trial, examining the comparative effectiveness of an anatomicalv versus functional testing approach to evaluate symptoms concerning for ischemia at leading academic medical centers, 89.8% of those undergoing stress testing had imaging performed *(Douglas et al., 2015).*

A broader administrative database found a similarly high 75% rate of imaging performed with stress testing *(Mudrick et al., 2012).*

Aim of the work was to determine the influence of coronary artery disease on heart rate recovery after exercise in patients with diabetes mellitus.

PATIENTS AND METHODS

The study was an observational, analytical study. Subjects were included in the study after meeting the inclusion criteria and after signing a consent form for enrolment.

Inclusion Criteria:

The study included all patients referred for Exercise stress test with suspected Coronary artery disease. And the indications for the stress test included: diagnosis and risk stratification of patients with suspected ischemic heart disease, monitoring patients throughout medical treatment or intervention.

Exclusion criteria:

All absolute contraindications of treadmill exercise stress test has been excluded: Symptomatic uncontrolled arrhythmia, patients with acute coronary syndrome, decompensated heart failure ,patients with EF<40%,pulmonary thromboembolism, acute pericarditis or myocarditis, aortic dissection, severe symptomatic valve stenosis ,uncontrolled BP (200/100 mm Hg), hypertrophic cardiomyopathy, high grade atrio-ventricular block, bundle branch block, and patients on β-blockers, C.C.BS and antiarrythmics.

The following parameters were measured in each patient: Blood pressure and pulse rate prior to exercise, during exercise and at protocol-established time intervals, as well as 1 and 3 minutes after the end of the stress test. Heart rate recovery time will be assessed in all groups.

All clinical and laboratory data has been assessed in subjects included in the study .All subjects had the following: (1) Full history taking with special interest in chest pain site, what increase, what decrease and precipitating factors, presence of diabetes. **(2)** Through Clinical examination. **(3)** Laboratory tests including fasting, post prandial blood sugar, HbA1C and lipid profile. **(4)** Resting 12 leads ECG. **(5)** Transthoracic echocardiography was done to determine the presence of regional wall motion abnormalities. Before the stress test, subjects were undergone Echocardiography using a Philips ultrasound machine. **(6)** Exercise Stress test using treadmill and Bruce protocol in the fasting state using GE machine.

In this study, we investigated and divided 50 patients in to 4 groups: Group (I)/ (n=20): Non diabetic patients with Normal stress test. **Group (II)/ (n=7):** Diabetic patients with normal stress test. **Group (III)/ (n=16):** Non Diabetic patients with positive stress test. **Group (IV)/ (n=7):** Diabetic patients with positive stress test.

Data analysis:

The data were collected, coded, revised, verified, and computerized. Statistical analyses were done using SPSS statistical package version 16. (IBM Corp, Chicago, IL, USA) Qualitative data were presented in the form of numbers and percentages and quantitative variables as mean and standard deviation (SD). A comparison between quantitative variables was carried out by the student ANOVA of two independent samples. Chi-square test (X^2) was used to compare qualitative variables.

RESULTS

There was no significant difference concerning baseline characteristics including age, sex, BMI, hypertension, smoking and basal (resting) heart rate **(Table 1)**.

Table (1): Baseline characteristics among groups

Variables \ Groups	Group (I) -ve DM -ve stress test (n=20)	Group (II) +ve DM -ve stress test(n=7)	Group (III) -ve DM +ve stress test (n=16)	Group (IV) +ve DM +ve stress test (n=7)	P-value
Age (year)	49.8± 17.3	40.6± 7.6	53.9± 9.4	49.1 ± 6.4	0.173
Sex, (male)	9 (45.0%)	5 (71.4%)	10 (62.5%)	4 (57.1%)	0.586
BMI (kg/m^2)	26.3 ± 3.3	27.1 ± 2.7	26.7 ± 3.5	28.1 ± 5.9	0.720
Basal heart rate	89.6± 8.9	97.0± 6.2	83.8 ± 15.2	88.0± 15.5	0.120
HTN (+ve)	5 (25.0%)	1 (14.3%)	9 (56.3%)	2 (28.6%)	0.135
SM (+ve)	1 (5.0%)	1 (14.3%)	1 (6.3%)	0	0.721

There was a significant delay in H.R.R in 2^{nd}& 3^{rd} min of recovery in groups 3&4. The significant difference and impact of ischemia on HRR caused heart rate recovery to be delayed. 2nd& 3rd minute of recovery has significantly

delayed (P. value< 0.01) more obviously in group 3 (+ve stress and -ve diabetic) that showed that ischemia affect more than DM. That indicated the negative impact of ischemia and D.M on time of recovery after treadmill exercise in 2nd and 3rd minute, also significant decrease in HRR%. Groups; + ve and -ve stress test patients revealed there was only significant delay in H.R.R in 3rd minute of recovery time. Concerning HRR%, it significantly decreased in positive stress subjects comparing to negative stress patients, Also, Duke Score obviously decreased significantly **(Table 2)**.

Table (2): Heart rate recovery time between normal stress test group and positive stress test group

Groups / HRR (P/M)	Group (I) Normal stress test (n=27)	Group (II) Positive stress test (+ve&-ve DM) (n=23)	P value
1st	22.5 ± 11.7	20.7 ± 8.8	0.543
2nd	16.6 ± 6.3	12.7 ± 6.2	**0.032**
3rd	11.3 ± 4.8	8.2 ± 6.2	**0.049**
HRR %	24.7 ± 9.3	20.5 ± 10.7	**0.040**
Duke score	5.27 ± 1.80	1.08 ± 1.44	**<0.001**

In correlation between H.R.R and Duke score,there was a fair correlation between basal H.R and duke score and significant correlation between H.R.R in 1st, 2nd, 3rd and HRR%. No correlation existed between HRR% and Duke Score, P.value was 0.295 **(Table 3)**.

Table (3): Correlation between HRR and Duke score

Correlation / Duke score	Correlation coefficient (r)	P value
1st HRR	0.44	0.002
2nd HRR	0.41	0.003
3rd HRR	0.62	<0.001
Basal HRR	0.26	0.048
HRR %	0.15	0.295

No significant difference between diabetics (group 2 &4) and non-diabetic groups (group 1 &3) except for the Duke score that was significantly different P.value <0.001 **(Table 4)**.

Table (4): Heart rate recovery time between non diabetic and diabetic groups

Groups / HRR (P/M)	Group (I) non diabetic (n=20)	Group (II) diabetic (n=30)	P. value
1st	23.7 ± 13.2	20.3 ± 8.1	0.268
2nd	18.0 ± 6.7	17.9 ± 9.1	0.401
3rd	11.5 ± 5.1	8.8 ± 6.2	0.114
Basal	89.6 ± 8.9	87.8 ± 14.4	0.637
HRR %	25.7 ± 10.4	25.5 ± 9.8	0.959
Duke score	5.26 ± 1.97	2.07 ± 2.28	<0.001

DISCUSSION

In the present study we evaluated the possible influence of diabetes mellitus and ischemic heart disease on HRR in patients who had treadmill exercise stress test. Although many variables in the univariate analysis were associated with HRR, in the multivariate analysis, only few were independently associated with HRR. There were no significant difference concerning baseline characteristics in all subjects including age, sex, basal heart rate, BMI, hypertension and smoking.

Yamada et al. (2011) showed that slow HRR after exercise strongly predicts SMI in patients with type 2 diabetes. Slow HRR similarly predicts myocardial ischemia at the microvascular and macrovascular levels. HRR was significantly associated with SMI and was also significantly associated with significant angiographic stenosis.

Our study, in comparing H.R.R in studied groups that were divided according to exercise stress test result and D.M, There was a significant delay in 2nd and 3rd minute of recovery time after exercise, revealing the negative effect of ischemic burden on heart rate recovery. So, ischemic heart disease patients had low HRR in 2nd, 3rd minute and HRR%.

Previous study showed that abnormal HRR is related to the extent and severity of coronary artery involvement, the calculated risk score for the exercise test, and smoking. Patients with abnormal HRR had lower functional capacity and lower peak heart rates, and they used less of their HR reserve at peak exercise. A normal HRR was independently associated with extensive CAD. These results suggest that abnormal HRR alone noted on stress ECG testing may have an independent value in predicting the extent of underlying CAD. an bnormal HRR is predictive for the presence of coronary artery disease, even in the absence of any specific ECG *(Samad et al., 2011)*.

Coronary angiography studies have demonstrated the existence of advanced atherosclerotic status in patients with reduced HRR *(Grad and Zdrenghea, 2014)*.

Regarding exercise time characteristic among all groups, there were significant reductions in capability of withstanding stress test in diabetic and positive stress test cohorts than healthy.

Regarding Duke Treadmill score, there was an obvious the significant reduction in diabetic and positive stress (group 3& 4) than in healthy cohort. So, it was very

important to identify Duke Score in all subjects who were known to be diabetic and suffering from repeated attacks of anginal chest pain along with studying H.R.R.

In comparing Duke Score between diabetic and non-diabetic subjects, we found that there was a decrease in diabetic than non-diabetic subjects, but not significant enough to be considered as an important index in diabetic but not ischemic patients.

Second and third minute of recovery time after exercise test were significantly affected in positive stress test patients. Also, HHR% significantly decreased and affected in the same group than negative stress subjects. Duke score significantly reduced in positive stress test group. Contrarly, we found no significant difference between diabetics and non-diabetics regarding HHR, but there was a significant difference in Duke Score only regardless of exercise stress result.

CONCLUSION

Delayed recovery and reduced heart rate recovery after treadmill exercise stress test was an available and important index for detecting and revealing the extent of ischemic burden.

Limitations: This study finding needs further assessment on big series.

Conflict of interest disclosure statement: Authors declare that; there was no any financial or personal conflict of interest.

Authorship (Authors' Contribution): All authors have made substantial contributions to the article.

REFERENCES

1. **Bourque JM and Beller GA. (2015):** Value of exercise ECG for risk stratification in suspected or known CAD in the era of advanced imaging technologies. JACC: Cardiovascular Imaging; 8: 1309–1321.
2. **Douglas PS, Hoffmann U and Patel MR. (2015):** Outcomes of anatomical versus functional testing for coronary artery disease. N Engl J Med 2015; 372: 1291–300.
3. **Fletcher GF, Ades PA and Kligfield P. (2013):** Exercise standards for testing and training: a scientific statement from the American Heart Association. Circulation; 128: 873–934.
4. **Fihn SD, Gardin JM and Abrams J. (2012):** ACCF/ AHA/ACP/AATS/PCNA/SCAI/STS guideline for the diagnosis and management of patients with stable ischemic heart disease. J Am Coll Cardiol., 60: 2564–603.
5. **Grad C and Zdrenghea D. (2014):** Heart Rate Recovery in Patients with Ischemic Heart Disease - Risk Factors. Clujul Med., 87(4): 220–225.
6. **Minkkinen M, Nieminen T and Verrier RL. (2015):** Prognostic capacity of a clinically indicated exercise test for cardiovascular mortality is enhanced by combined analysis of exercise capacity, heart rate recovery and T-wave alternans. Eur J Prev Cardiol . 22: 1162–1170.
7. **Mudrick DW, Cowper PA and Shah BR. (2012):** Downstream procedures and outcomes after stress testing for chest pain without known coronary artery disease in the United States. Am Heart; 163:454–61.
8. **Murphy SL, Xu J and Kochanek KD. (2013):** Deaths: final data for 2010. Natl Vital Stat Rep., 61:1–117.

9. **Samad Gh., Babak K and Parvaneh A. (2011):** Cardiovascular Research Center, Tabriz University of Medical Sciences, Tabriz, Iran. Cardiology Journal, Vol. 18, No. 1, pp. 47–54.

10. **Sharma K, Kohli P and Gulati M (2012):** An update on exercise stress testing. Curr Probl Cardiol; 37: 177–202.

11. **Yamada T, Yoshitama T, Makino K, Lee T and Saeki F. (2011):** Heart rate recovery after exercise is a predictor of silent myocardial ischemia in patients with type 2 diabetes. Diabetes Care, 34:724–726.

زمن افاقة ضربات القلب فى اختبار الاجهاد القلبى البدنى بعد مرضى السكرى المشتبه اصابتهم بقصور الشريان التاجى

أحمد زين العابدين محمد ، محمد أسامة فتحي قايد ، محمد سامي عبد السميع

قسم أمراض القلب، كلية الطب، جامعة الأزهر

خلفية البحث: تحسين الشفاء بعد التمرين يعد أمرًا حيويًا لتقليل معدل الوفيات القلبية عن طريق التحكم في الجهاز العصبي البارسمبتاوي في وقت الشفاء.

الهدف من البحث: تحديد تأثير مرض الشريان التاجي على استرداد معدل ضربات القلب بعد التمرين في مرضى السكري.

المرضي وطرق البحث: تم الحصول على الموافقة الأخلاقية من لجنة البحوث الأخلاقية بالمستشفى ووقع كل مريض على موافقة مستنيرة. وتم أدرج خمسين مريضا في هذه الدراسة مقسمة إلى 4 مجموعات. كل ذلك مع عدم وجود تاريخ واضح لمرض القلب الإقفاري. وقد تم إجراء تاريخ تفصيلي، الفحص البدني، تخطيط القلب أثناء الراحة وتخطيط صدى القلب عبر الصدر، وإختبار إجهاد تمرين المشي في النهاية. وفي هذه الدراسة تم تقييم استرداد معدل ضربات القلب في الدقيقة الأولى والثانية والثالثة، وكذلك معدل ضربات القلب القاعدية المدرجة.

نتائج البحث: حدث تأخير كبير في وقت الشفاء من معدل ضربات القلب لدى مرضى السكري مع اختبار رسم القلب بالمجهود البدني للضغط الإيجابي لنقص تروية عضلة القلب.

الاستنتاج: التأخير في الشفاء وانخفاض معدل ضربات القلب بعد اختبار الضغط على ممارسة الجري هو مؤشر متاح وهام لاكتشاف وكشف مدى العبء الإقفاري.